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ABSTRACT

This publication is part of the study materials for the distance education course, Adults Learning: The Changing Workplace A, in the Open Campus Program at Deakin University. The first part of the document examines the relationship between technological change and skills development. The following topics are discussed: the new technological revolution and its effects on public institutions; the positive potential and negative aspects of new technology and necessary choices; defining technology (the significance of the labor process and technological determinism); social transformations of technology (the examples of telephone companies and IBM and exposing the myth that technology is always progressive); the systems life cycle (criticisms of the traditional design method and worker involvement in systems development); the social mediation of skills (stages in an administrative revolution and the progression from the mechanical office to the paperless office); and the cycle of labor transforming technology transforming labor. The first section contains seven references. The following papers constitute approximately 80% of the document: "Educational Implications of High Technology" (H. M. Levin, R. W. Rumberger); "Office Technology as Exile and Integration" (S. Zuboff); "Social Choice in Machine Design" (D. F. Noble); and "The Material of Male Power" (C. Cockburn). Concluding the document is a 12-item annotated bibliography. (MN)

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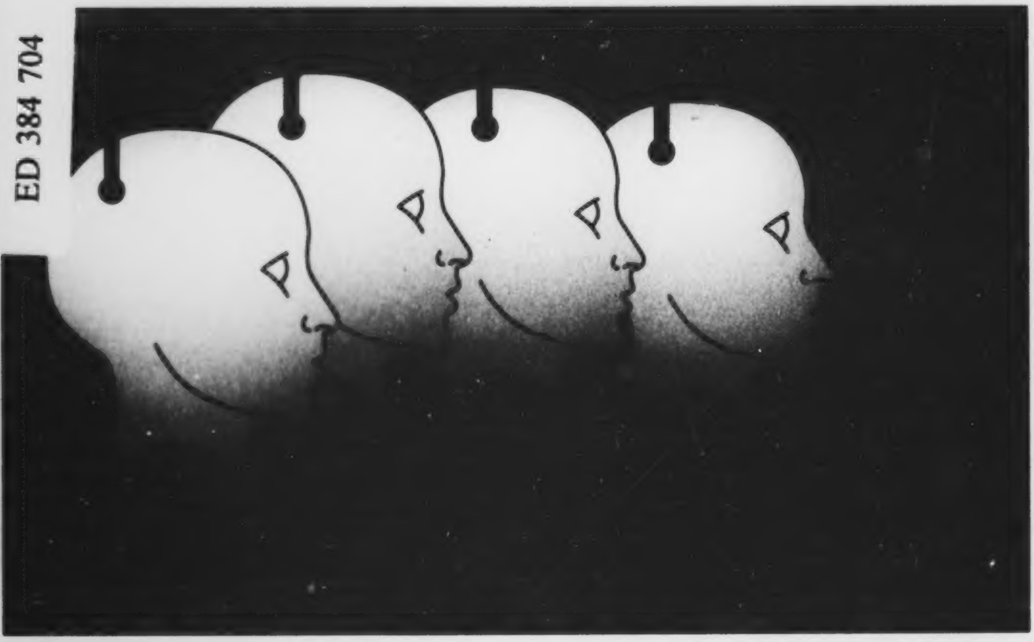

TECHNOLOGICAL CHANGE AND SKILLS DEVELOPMENT

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EEE700 ADULTS LEARNING: THE CHANGING WORKPLACE A

TECHNOLOGICAL CHANGE AND SKILLS DEVELOPMENT

ELAINE BERNARD

This book forms part of EEE700 *Adults learning: The changing workplace A* which is one of the units offered by the School of Education in Deakin University's Open-Campus Program. It has been prepared for the *Adults learning: The changing workplace A* team, whose members are:
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SERIES INTRODUCTION

The nature and purpose of education in the workplace has been the subject of much debate in Australia in recent years. While the vagaries of local and international competition have led many firms to reconsider the role of their workforce and the training requirements this entails, governments have been equally keen to adapt existing education systems to the perceived needs of industry. Leading union bodies have been distinguished in this debate by their pro-active role, outlining the path by which a reconstructed industrial climate can win the nation a new place in the world economy.

The series of monographs of which this volume is a part explores the approaches to learning currently modeled within industry. In the process the question inevitably arises as to whether existing orientations and practices are in the best interests of the various stakeholders in the workplace.

The arguments developed in these monographs address themselves to a range of contemporary issues in industrial education. To date, prevailing approaches have rested upon narrow, instrumentalist notions of learning; in their different ways, the writers have set out to challenge this orthodoxy. In doing so, they highlight the silences—on questions of gender, class or ethnicity—that underpin the behavourist outlook still dominant in the world of training.

In preparing this series of monographs, the course team has sought to address issues that are of fundamental concern to those involved in the complex and demanding field of workplace learning. It is hoped that, in its own modest way, the pedagogy we have developed can serve to exemplify a different notion of what industrial education might become.

TECHNOLOGICAL CHANGE AND SKILLS DEVELOPMENT

Introduction

Today we live in an age of constant and rapid change. There is a Chinese saying about such periods in human history, 'may you live in interesting times'. It sums up wonderfully the ambivalence that most people feel about life in the 1990s. We are certainly experiencing 'interesting times', and for many it does appear to be more of a curse than a blessing.

'Interesting' may be the best term to describe our contemporary period as there is not much agreement among scholars and commentators about the nature of the changes that we are going through as a society. There is even less agreement about the nature of the society into which we are evolving.

New technological revolution

James R. Beniger, author of *Control Revolution*, a book about the emergence of the 'information society', lists seventy-five names or expressions used by analysts to refer to this 'new age'. These labels include such familiar phrases as the 'global village' and the 'third wave'. Another popular way to generate new terms is to link a new machine or material with the word 'age', resulting in, for example, the 'robot age', the 'computer age', the 'silicon age', the 'microelectronic age', the 'communications age' and the 'information age'. But an even more popular choice is to use some term with the word 'society'—producing the 'information society', 'telematic society', 'post-industrial society', 'service-class society' and 'post-capitalist society' (see Beniger 1986, pp. 4–5).

One of the problems in giving a name to these changes is that we are still uncertain about the direction in which we are heading. Referring to the present period as a new age or a new society also implies a major break with the past. Clearly, one could argue that human history is full of change, and that throughout human history there have been periods of rapid transition in technology and social relations. Today, however, there appears to be something unprecedented in the pace and breadth of the change we are experiencing. Taken together, these transformations in the workplace and in our society constitute a new social revolution, similar in impact to the 'industrial revolution' of two centuries ago. No matter what label future generations give to the latter half of the twentieth century, it will clearly be remembered as a time of major change and social transformation.

The industrial revolution saw the shift from a rural, agriculturally dominated society to an urban, industrial society. As a result of these changes, a mass class of wage-earners, dependent on selling their ability to

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work, was created. Mass transportation systems for the moving of goods, systems of electric power distribution and communications networks formed the infrastructures of a mass commodity-producing and commodity-exchanging society.

As with the industrial revolution, the changes we are currently experiencing have their roots in an earlier period. Much of our present understanding about our society and the institutions that mould our lives is the product of a world constructed after the industrial revolution.

The effects on public institutions

Public schools in the Western world are an example of an institution that is shaped to meet the needs of the past. It has often been said that today we have an education system suited to the needs of the industrial revolution. The underlying assumption is that school is primarily for young people, and that most of us will complete our formal education in our youth. Everyone is expected to attend school full-time from the age of five until sixteen (though increasingly we are entering schools earlier and leaving them later). In their early teen years, students will make a lifetime career decision (sometimes by their own choice, but most often through courses and institutions designed to give them a certificate or licence of completion). Even the very structure of schooling—compulsory, full-time study, with summers off for good behaviour—is preparing students for the world of work as employees and to make them obedient, literate workers.

Today, we recognise that most of us will be going through a number of career changes in our lifetime. Futurists predict that workers entering the labour market today will experience an average of seven or eight major career changes in their working life. Increasingly, workers from all walks of life will need to become lifelong learners, moving in and out of formal educational environments and acquiring new skills and knowledge throughout their careers. But our publicly funded educational institutions are not structured or designed to support the adult learner.

Similarly, the majority of social programs in the Western world, pensions and benefits are designed to meet the needs of a previous age in which workers were expected to be less mobile. For example, vacation time and other benefits are often tied to an individual's seniority with a particular company or firm, but not to his or her age, a situation which effectively penalises a worker for changing jobs. Similarly, pensions are rarely fully portable. A change of employer or a middle-life break in employment can result in a significant reduction in retirement income. With the exception of a few occupations (e.g. teaching) workers are rarely permitted extended leave from work for additional education.

As we begin to discuss the transformation, which is taking place in work and work organisation, it is valuable to consider carefully the changes which will be necessary in our institutions. We will also need to consider how to protect workers while simultaneously deriving the maximum benefit from the new technology for the wider society. Discussions about technological change are full of the language of costs and benefits, but it is not enough to ask: 'what are the benefits?', 'what are the costs?'. The appropriate question can be better framed as: '*whose* benefits and *whose* cost?' (Franklin 1990, p. 124)

Crossroads

Our world has not yet been fully transformed by the new work practices, relations and technologies of the 'information age'. While we can point to specific examples of dramatic changes, such as the proliferation of microcomputers in homes, offices and schools, the information revolution is still in process. This makes our age a very exciting one in human history: a time when major changes are taking place and when we can make dramatic breaks with the past.

It is for this reason that many of the authors writing about the present describe us as being at a 'crossroads' of technological change. Although the new technology holds marvellous potential to benefit workers, and all of society, many people in the workplace have experienced problems associated with its introduction and application. Let me briefly review some of the positive and negative features, and the potential of technological change as it is currently being introduced into the workplace.

Positive potential of new technology

A great hope for new technology lies in its potential for eliminating or reducing dangerous work, through either the complete automation of dangerous jobs or the close monitoring of work and working conditions in these environments. Liberation from strenuous, dangerous work has long been a dream associated with technology, even during the industrial revolution. With the coming of the 'age of information technology' there is, for the first time, an opportunity for emancipation from tedious, repetitious and mindless work as well. The industrial revolution created strong machines, the new 'information age' is now witnessing the development of 'smart' ones (see Zuboff 1988).

In addition to freeing people from mindless work, information technology promises potentially limitless access to information. The new ways of acquiring, analysing and presenting information have already started to create new jobs and products.

Some workers can see their skills increasing as they learn to use and modify new systems. As more information is captured electronically, the ease and speed of transmission of this information as compared to telecommunications networks makes it possible to transfer information and work around the globe. No longer will workers in a myriad of occupations and professions have to travel to an employer's place of work. They can 'telecommute', by accessing their work remotely from the location of their choice. Through telecommuting, students, researchers and the like have access to libraries, databases and information sources from around the world. From an energy-conservation perspective, telecommuting will mean tremendous savings, with the potential to end the 'gridlock' of cars and other motor vehicles during rush hour in our cities.

Information stored electronically takes a fraction of the storage space (as well as heating and energy requirements) that traditional paper-based systems require. Electronically stored material has tremendous flexibility. It can be searched, compiled and reformatted endlessly to meet a multitude of user needs and interests. It can be copied and recopied rapidly and at a fraction of the cost of paper-based systems. Entire libraries of materials can be stored on a few computer tapes.

Computer-based systems are significantly cheaper, more energy-efficient and conserve more raw materials than previous technologies. They are also one of the few products for which prices are falling as their capacity and utility continues to grow. The savings achieved by the use of computer-based systems can be multiplied when combined with work reorganisation to eliminate wasteful duplications of records and information.

In manufacturing and industrial production, flexible systems can both reduce the down time and set-up time of machinery, as well as increase the flexibility of production. The speed and accuracy of new systems can in turn significantly increase productivity, which holds out the potential for both increased leisure time as well as overall cost reduction. The combined speed in information processing and flexibility can reduce waste in production and in the cost of inventories through new methods of production, such as 'just-in-time' delivery systems.

Another important area offering tremendous potential for the positive applications of new technology is the provision of products and services for the disabled. Computer-based systems could provide much assistance to the mobility, hearing, speech and visually challenged.

Negative aspects of new technology

On the negative side, the rising level of unemployment and an overall employment shift associated with new systems is the foremost concern. The downside of 'labour saving' and 'increased leisure time' can be unemployment for those whose labour is displaced. The introduction of new technology has both eliminated as well as created jobs. Neither is it accurate to assume that the new jobs created by new technology are 'high tech' and well-paid, and not all the jobs eliminated are mindless or dangerous. There is no guarantee that the workers displaced by new technology will be able to re-enter the job market and take up the new positions created by technological change. Often the skills required in the new jobs are totally different to the old skills replaced by automation.

Many of the jobs that are currently being eliminated by automation are well-paid, semiskilled production jobs in manufacturing. Much of the new employment, on the other hand, is in the unorganised and poorly paid service sector. In addition, there is an overall increase in part-time work, often at the expense of full-time jobs. We are also seeing the introduction of shift work and clerical work where it has not traditionally been part of an industry.

These workers are the victims of new technology and are hidden from view in the discussions about its positive aspects. In spite of the potential for eliminating tiring, repetitious jobs, new technology in many cases has actually contributed to the loss of skills (deskilling) and decrease in job satisfaction through the isolation of workers. Workers on new information systems often complain that they have no control over their work, that machines now govern their daily pace. As more and more work becomes machine-regulated, people may increasingly become alienated from their jobs, coworkers, clients and customers.

Telecommuting and work-at-home have prompted the reintroduction of 'cottage industries', only this time in information processing. It is feared by many that a return to work-at-home will undermine much of work's social aspect. Conversely, what happens to the character of our homes when they are converted into places of work? For organised labour, there is another problem. As work moves away from centralised locations, and a large, permanent, full-time workforce to temporary, limited-term, contract employees, there are major difficulties in organising the new workers. For the whole of society, we must ask how working conditions and workers' rights will be protected when workers are physically isolated.

The ease with which computers can monitor work and the worker, which is an important safety factor and bonus for workers in dangerous environments, can become a gross invasion of privacy and a source of tremendous anxiety when used as electronic surveillance. In clerical occupations, employees' work performance can be constantly measured, even to the individual key stroke and fraction of a second. This intensive surveillance is stressful and has led to new concerns over the invasion of privacy and the civil rights of workers. There are also a number of occupational health and safety concerns related to stress from a machine-regulated pace and electronic monitoring, as well as injuries from rapid repetitive motions associated with electronic keyboards and the speeding up of work.

Choices

How do we take advantage of technology's positive potential for transforming our lives and our world while at the same time avoiding the negative effects? Is it simply a matter of voting for one or the other option? If we see technology as a human process, one shaped and fashioned by social decision-making, then it is not a question of simply predicting the future, or of watching and waiting to see if the positive potential wins out over the negative. People today are making choices about technology in their workplace, schools and homes. These decisions will influence our future options and decisions. In this sense, we are in the process of making the future rather than simply predicting it.

Choices about appropriate technology are exercised in a number of different ways, although not all options are equally plausible at any given point. We make choices about technology through our purchasing power in the marketplace; by political means, through voting, lobbying and influencing regulation and programs of government; and collectively, in the workplace as members of unions or employee associations.

Clearly, we are not all equal in our influence in the marketplace. Large companies and major purchasers have significantly more influence than individuals. Often, technological choices exercised in the workplace have a profound effect on the direction of technological development and on our social choices. For example, when the largest computer firm in the world, IBM, decided to enter the personal computing market, its equipment quickly became the industry standard.

Also, we are limited in our purchasing power to that which has already been produced. For example, it is difficult to opt, as individuals, for mass rapid transit through the marketplace if this option is not available. While it may seem that we have endless choices in technology, the market steers the choices in a particular direction. A major direction in today's computing industry is the move toward displacement of labour and toward developing 'smart systems' or 'expert systems' which capture and process immense amounts of information. These systems will permit highly skilled operators to have even greater access to information, and they may also permit 'expert' behaviour and mastery of complex tasks or subjects by unskilled labour.

As a good general rule the earlier in its design and development stage that influence and demands are placed on a particular system, the easier it is to bring about change in that system. A good illustration can be seen by looking at the development of the typewriter keyboard.

The oldest design component of any computer is the layout of the keyboard. The rather peculiar configuration found on any standard keyboard is termed 'QWERTY', in reference to the order of the first six letters on the top row of keys. This configuration was developed and patented in 1867. Before the QWERTY design was adopted, the first keyboard designs were simple alphabetic layouts (elements of which can still be seen with GHJKL all in a row). But it was found that once a typist developed any speed the type bars jammed using this configuration. So, a study was commissioned to determine the frequency of letter combinations in the English language, and the keyboard was redesigned to assure maximum separation of frequent combinations. That is why, for example, the letter E (the most frequently used letter in the English language) is on the left-hand side of the keyboard and on the upper row, not on the home row. This keyboard configuration was deliberately designed to slow the typist down. In a mechanical age, where typists' skills could quickly outstrip the typing machines capacity, the QWERTY configuration was an appropriate response to the technological limits of the day. Today, however, with electric and electronic keyboards the speed limitations of the mechanical keyboards have long since disappeared. In the 1930s a scientific board, Dvorak, was developed with a key configuration designed to maximise typing speed. But with millions of typists trained on QWERTY, the new board never caught on, in spite of the fact that it improves typing speed.

There are many obstacles to the positive approach to the design, implementation and use of new technology. One of the major problems in trying to understand technological change is that technology is one of the most mystified of topics. It ranks second only to the economy as a phenomenon which is constantly talked about in a context that is guaranteed to make people feel like powerless victims (of technological change or of economic forces). How are normally self-assured citizens turned into shy, passive victims by technological change? Simple. The term 'technology' becomes a catch-all phrase for a variety of new equipment, organisational changes and reconstruction of work. Technology becomes synonymous with science and progress. Who could question science? Who would want to question progress?

For all the attention given to technology, it is rarely ever defined. This is also part of the mystification process. If we do not really know what it is we are talking about, then confusion is not only understandable, it is inevitable.

Defining technology

A first step in demystifying technology is to define exactly what we mean by the term. Generally, we tend to use 'technology' to refer primarily to machines. But technology is much more than hardware, machines and artifacts (things we can kick). Technology is also applied to systems, structures and methods. It is the ways in which we, as a society, organise ourselves in productive enterprise. It is infrastructures as well as artifacts. In computer terms, it is the software as well as the hardware.

The definition which we will use is: 'technology is the means and processes through which we as a society produce the substance of our existence'. This definition sees technology as fundamentally a human process with human choices and decision-making at the centre. It describes technology as a system, not simply as artifacts or processes in isolation. In broad categories, we can include in our definition of technology five specific items: tools, materials, energy forms, techniques and organisation of work.

While these five elements are all components of technology, some items have been historically more readily identified as technology than others. This itemised definition is useful for more than simple academic accuracy. Since technology is so often mystified in our society, a look at its components allows us to see the pervasive nature of the social transformation captured in the concept of technological change. So, let us look in turn at each of the five elements included in our definition of technology.

Tools are the most obvious category. For most people, tools are synonymous with technology. They are readily identified as the rise of civilisation and human development through tool-making, or as the new tools being introduced into the modern workplace, such as robots and computers. History is full of examples of the significance of particular tools in human and social development (e.g. the role of the stirrup in military history, giving the rider considerable stability and balance and contributing to military superiority, or the role of a particular shape or design of plough leading to greatly improved planting, tilling methods and harvests). Few would dispute that tools are a part of technology but it is important to recognise that technology is much more than tools—no matter how simple or complex the tool may be.

New materials, for example, can be almost as significant in their social impact as new tools, but changes in materials are less often recognised as important components of technology. Historically, of course, we have referred to materials (especially metals) to demarcate stages in the development of ancient societies—the Stone Age, the Iron Age and the Bronze Age. Increased sophistication in the making and refining of materials was judged as a demonstration of progress by ancient societies.

In this century, we have experienced some important revolutions in the use of materials. The 'computer age' is often called the 'silicon age', referring to the use of silicon as the material from which computer chips are built. But the computer industry is not the only one to have gone through a materials revolution. If we think of technological change in some of the building trades and in construction, for example, the replacement of metal and wood by plastic has been a major component of technological change. Likewise, the changeover from metal to plastic piping has resulted in a major change in plumbing. The introduction of fibre optics has made it possible to replace metals in communications wiring. In car engine blocks, new ceramic materials are being used.

Identifying new energy forms has been another way that we have traditionally described technological revolutions. The industrial revolution is often referred to by one of the power sources harnessed in this period, the 'steam age'. There was, of course, steam before and after the 'steam age', but harnessing steam as a portable energy form revolutionised production and transportation during the industrial revolution. Today, of course, there is much talk about the prospects for nuclear energy, but the major source of power in the information revolution remains electricity, regardless of whether it is produced by coal, hydro-or nuclear power.

Technique is a more complicated technological concept than any of the other elements described so far. By technique, we essentially mean new or different methods of doing things. A good example is in the construction industry. Here, the use of concrete as a building material has been greatly enhanced by reinforcing it with steel. Neither material is new, but using steel mesh and beams to reinforce concrete was a change in technique which greatly increased its utility in construction.

The last element of technology in our list is unquestionably the most significant in its social implications. We have used the term 'organisation of work' to capture a large variety of methods, structures and hierarchies associated with technology. By the phrase 'organisation of work', we are not referring specifically to unions, but to how labour in general is organised to use those tools, materials, energy forms and techniques that produce the goods or services which we, as a society, need in order to survive.

The significance of the labour process

As with some of the other elements of technology, the dominant methods of organising work have often been used to characterise specific periods in social development. Work organisation can have a profound effect on our lives. For example, the fundamental difference between craft and assembly-line work does not involve a change in tools, materials, energy forms or techniques, but a change in work organisation. The first assembly lines were organised by restricting workers to a position on a bench or on the shop floor. Individual workers were told precisely what to do. Complex assemblies were divided into a multitude of separate steps and individual workers were assigned one or two tasks to be constantly repeated at a carefully monitored rate throughout the day.

This type of precisely organised, supervised, timed and measured work was termed 'scientific management' or 'Taylorism' after one of its originators, Frederick Winslow Taylor. Eventually, this type of work organisation came to be the dominant method in mass manufacturing, especially in leading sectors of the economy such as automobile manufacturing. Later, the whole economic model dependent on this mass production method was termed 'Fordist' after US automobile manufacturer and entrepreneur, Henry Ford.

The term 'craft' has been used to describe an organisation of work where the worker maintains control over his or her product throughout the production process. Craft workers, whether cabinet makers or computer programmers, follow the product through all of its stages from inception to final output. Independence of action and a great deal of control over the labour process is associated with craft work. The skills acquired by craft workers are neither employer-specific nor job-specific, and thus permit craft workers a good deal of flexibility in the job market and the general transferability of skills. Today, many of the jobs which fit the craft model are professional occupations.

For most workers, management-determined work organisation can be the most significant factor in influencing their use of technology. Often the constraints, which are seen as the limitations of the technology, are conscious management choices in the design of work. For example telephone operators, through the use of computer databases and electronic switching networks, have access to far more information and systems capacity than their designated job of simply giving telephone numbers for directory assistance. Yet, in most instances when contacting the telephone company, you must speak to the accounts office for billing information, a different office for reporting problems with your telephone and yet another area for the long-distance operator or directory assistance. This is an example of how the old Fordist labour process, with its strict division of labour and separation of tasks, has been reproduced using the new technology.

When we talk about choices in the design, development and use of technology, we must include the organisation of work in our definition. It is in the area of work reorganisation that there is tremendous positive potential for new technology.

Technological determinism

Aside from the practice of mystifying technology by not defining what we are talking about, an additional form of mystification sees technology as an untouchable, natural force. This is referred to as technological determinism and is reflected in the widely held belief that technology is unbiased, inevitable and progressive. A technological-determinist stance tends to contribute to the feeling of victimisation which many people have about technology. Rather than thinking critically about technology in terms of how it was constructed, under which specific conditions and how it can be changed, technological-determinist attitudes assume that the individual, not the system, must change. This view rather confuses the subject with the object. It demands that people must learn to serve technology, rather than learn to fashion technology to fit human needs. Debunking the myth that technology is unbiased, inevitable and progressive enables us to work creatively with technology and, when necessary, to change it.

To deal with the question of 'bias', we should return to our definition of technology as a human process. We tend to see technology as machines, hardware and artifacts, and therefore have a great deal of difficulty trying to imagine inanimate objects as having biases. But let us look at a very familiar example: hand tools. Mass-produced hand tools are most often designed and constructed to fit an average male right hand. Left-handed people can immediately spot one of the biases in hand tools and, in fact, there are now many tools that offer right or left grips. For women, too, many hand tools feel awkward, uncomfortable and difficult to manage. It may very well be because the grips are simply too wide or thick to permit efficient control by an average woman's hand. This is a very simple bias. For the most part, it can be easily remedied by reducing the grip size. But, what is important is the recognition that even something as inanimate as a hand tool is full of human biases and assumptions, not only about the use of the tool, but also about the tool user.

When we get to more complex machinery, such as computers (tools that often include forms of work organisation as part of their design) the bias is initially a little more difficult to spot. Yet, if we look at any large computer system manual, we will discover that much of the content is not about 'how to do things' but more about the hierarchy of who is 'permitted' access to which levels in the system.

We are not accustomed to looking for biases in technology. On the other hand, most of us are well schooled at reading text critically. We readily identify written work with an author and ask questions about the author's viewpoint. We know that when an author writes a book, for example, that person will have a specific point of view. Depending on his or her view of world affairs, unions or the economy, the author's bias will show in the choice of facts, emphasis and approach of the final product. In a similar manner, when an engineer, designer or technician designs a machine, his or her biases will appear in the hardware and software produced.

It is a fair assumption that the vast majority of people currently designing technology will never have to use these machines. In the office equipment area, for example, the majority of designers have never worked in offices and have very little idea of what the day-to-day job of a clerical worker entails. Furthermore, they design the equipment for the purchaser (usually management) who may never have to use it either. It is not usually designed for the end user, the worker. Similarly, a lot of factory and production equipment is designed with controls in awkward positions, forcing the operators to fit themselves to the machine rather than fitting the machine to the operator.

Many of the current technological designs reflect an underlying prejudice against workers. They are designed with the assumption that workers are lazy, stupid and incompetent. Many systems designers believe that workers will purposefully destroy or undermine systems if they have too much control, and much effort in design is aimed at 'worker proofing' or even 'idiot proofing' technology. This is hardly a design prescription for social advancement or a technology for liberating humankind.

If you think this criticism is harsh or an exaggeration, consider for a moment the following quote from Boguslaw:

> Our immediate concern, let us remember, is the explication of the operating unit approach to system design, no matter *what* materials are used. We must take care to prevent this discussion from degenerating into a single-sided analysis of the complex characteristics of one type of system material: namely, human beings. (Boguslaw 1965, p. 112)

What we need is an inventory of the ways in which human behaviour can be controlled, and a description of some instruments that will help us achieve control. If this provides us sufficient 'handles' on human materials, so that we can think of them as one thinks of metal parts, electric power or chemical reactions, then we have succeeded in placing human materials on the same footing as any other material and can proceed with our problems of system design. Once we have equated all possible materials, one simply checks the catalogue for the price, operating characteristics and reliability of this material, and plugs it in where indicated. For an engineer or industrial designer, these are precisely the terms upon which human beings must be considered. This is not, of course, to imply that engineers are cruel, heartless or inhuman. They are, as they would put it, 'simply trying to do a job'. It is, they would assert, 'inhuman' to insist that human beings perform duties that can be passed on to nonhuman materials. This frees human beings for golf, philosophy, music and business deals:

> There are, however, many disadvantages in the use of human operating units. They are somewhat fragile; they are subject to fatigue, obsolescence, disease, and death; they are frequently stupid, unreliable, and limited in memory capacity. But beyond all this, they sometimes seek to design their own system circuitry. This, in a material, is unforgivable. Any system utilizing them must devise appropriate safeguards. (Boguslaw 1965, p. 114)

Clearly, a bias which sees workers as mere components in the production process will not lead to a systems design which augments the workers' knowledge and control of the workplace.

Social transformation of technology

When faced with a technological system, which clearly does not fit the task, workers have shown tremendous inventiveness and ingenuity in attempting to adapt inadequate machines to their needs. The history of technology and innovation is full of shop-floor developments which reflect the underlying bias against workers' adaptiveness and control of technology. Part of this is related to the Fordist model of production, which is exemplified by Boguslaw's description of the need in engineering to guard against '[material] sometimes seek[ing] to design their own system circuitry' (Boguslaw 1965, p. 114). Part of it is related to a more general belief that the progress of technology is inevitable and any attempt to change it is futile and inappropriate.

The view that technology is inevitable is often used to undermine attempts to slow down or change specific designs and implementations of technology. Concerns over occupational health and safety hazards, employment security and the environment are all swept aside by the 'inevitability' of technological change. Yet, there have been many examples of technology being transformed by mass resistance and/or other forms of public or work pressure. Technology, like any other product of human labour, is socially negotiated and mediated. The development of the telephone as a means of near-universal, private communication, and the rise of the personal computer, are both good illustrations of the social mediation of technology, and of the popular usage of a product moving its development in a different direction to that which the initiating companies had foreseen.

Telephone

When the telephone companies first started to market a telephone service, they promoted the new technology primarily among business and professional people. The equipment was expensive and, for that reason, the early companies did not envision telephones as a virtually universal instrument of distance communications. With a small number of users, they strictly monitored the network for misuse of the new technology. They were particularly alert for 'idle chat' and 'socialising' by women, which they felt were mischievous misuses of a business and professional network. Today, of course, we hear no such complaints by the telephone industry against the social communications in which subscribers engage. The telephone industry now encourages people to 'reach out and touch somebody'. Chat away, for as long as you like, and with someone as far away as you can afford. Social demands on the technology transformed telecommunications from an exclusively business and professional tool for a small minority to a near-universal, private, communications tool for the majority. The telephone as we know it today is the product of complex social interactions and transformation (see Martin 1988).

IBM

Like the telephone companies of the nineteenth century, large computer manufacturers of the early 1970s were slow to exploit the potential of computer technology. It was not the computer giant IBM or any of the large computer firms that introduced the microcomputer. IBM, in particular, disparaged the micro-(personal) computer, arguing that the (inevitable?) future of computing rested with users leasing time on a few large computers in major centres. Today, of course, the microcomputer market has reached a point where the most advanced microcomputers have buried the micro- versus mini-distinction and the most recent generation is providing stiff competition to some mainframe computers. Again, here is an example where change may have been inevitable, but it did not go in its initially intended direction.

Today, of course, both the computer and the telephone industry give the impression that the way their industries evolved were 'inevitable'. IBM went so far as to name its first generation of microcomputers 'the personal computer' and today proudly claims to have launched the personal computer revolution. But both these accounts illustrate the tremendous opportunity for fashioning and molding technology if enough social pressure can be applied at the earliest stages of its development.

Whose progress?

The hardest myth to debunk about technology is that it is always progressive. Despite the number of instances of machines being used to replace and monitor people, as well as regulate the pace, quality and rhythm of work, the vast majority of workers still accept the myth that all technology means progress (even if they see no visible sign of it in their own lives or workplace). Technology can of course lead to tremendous progress, but this progress must be measured in human terms. We must ask *who* benefits and at what cost. Questioning technology in this manner can assist in the design and development of more socially appropriate technology, since it forces designers to take into account all the people involved, not just the purchaser.

Let me use an example from the previous century to illustrate my point. In the early 1800s coalmine owners in England approached a scientist, Humphry Davy, to assist them in reducing methane gas explosions in mines. Davy developed the 'Davy miner's safety lamp' which enclosed an open flame in fine wire netting, thereby cooling the heat from the flame to below methane's ignition point. The company heralded the invention of the Davy safety lamp as a fine example of technological progress, and even today it is often used as an example of science and industry working together to improve life for us all.

But, from the miner's point of view, the Davy safety lamp was a disaster. Use of the lamp led to an increase in explosions and hence fatalities in the mines. It made it possible for company bosses to force workers into more gas-intensive environments, that would have been totally inaccessible before the invention of the 'safety lamp'. But most important, it allowed the mining companies to forestall the real improvement in mine safety, proper ventilation. Technological progress must be measured on a human scale. The Davy safety lamp may have led to increased profits for the mine owners, but it certainly was not a progressive step for the miners (see Albury & Schwartz 1982, pp. 11–24).

Aside from these general social attitudes toward technology, there are a number of specific problems in attempting to assert some control over decision-making with regard to technological change. Our model of collective bargaining, for example, has held that management has the right to choose the tools, materials, energy forms, techniques and organisation of work. Labour will essentially bargain the price of compensation for hours worked, skills acquired and years of service. The presumption is that management initiates and labour responds. Yet, increasingly, today we must recognise that in order to fashion a technology that will meet the needs of all of us, workers must have a voice in decisions about the use of technology in the workplace. If new technology is going to be designed as a tool of liberation, worker participation in decision-making cannot simply be added on. It must be integrated throughout the design, development and implementation cycle. We cannot be a society of obedient, powerless employees during work and free and powerful consumers after working hours.

The systems life cycle

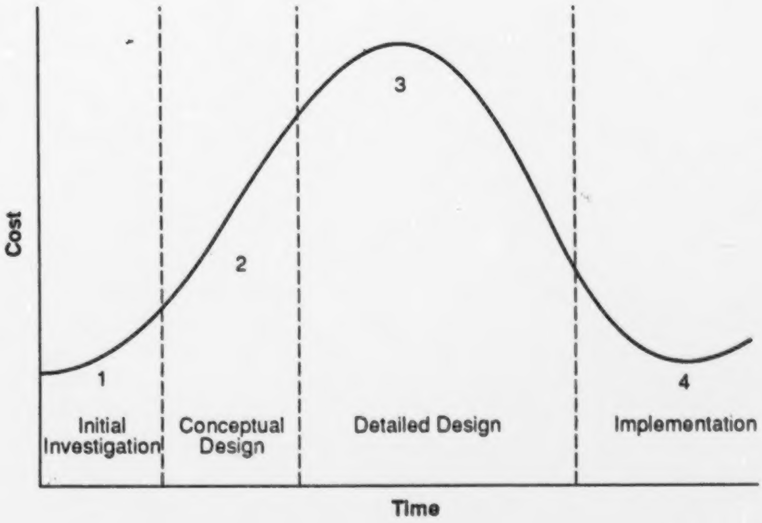
If workers are to be involved in technological decision-making, we need to revise our traditional method of development and introduction of new technology. The 'systems life cycle' has been the traditional method by which technological change is introduced into a workplace. Variations of this 'life cycle' are taught in business, engineering and computing schools. The stages in the cycle sometimes vary with different models, but the essential structure and process remain the same. Figure 1 illustrates the basic model of a system life cycle—a standard bell-type graph, in which the X axis is time and the Y axis is cost.

The first stage consists primarily of senior management working with outside consultants (or assigning in-house staff to do a work study) to assess problems and make recommendations for the scope of further action. At this stage, workers are generally not consulted or informed that a study is taking place, since such planning and change are widely viewed as management's prerogative.

In the second stage a conceptual design is developed. A detailed study is undertaken to determine how information is currently processed and/or how goods and services are produced. This is usually done though questionnaires, interviews, gathering documentation and observation. Then, a new system of work flow and methods is proposed, with recommendations on hardware and software, a time line, costs and solutions to the problems identified in stages one and two. At this point, individual workers are often the subject of interviews, questionnaires and studies. But the workforce as a whole is not usually informed of impending changes.

Detailed design is stage three. At this point, recommendations are adopted, hardware is published and programs are written. Workers are often lulled into believing that the earlier signs of impending change, such as work-site visits by consultants, were false alarms. But by this stage the organisation involved in technological change invests considerable funds in the signing of contracts with suppliers and vendors and the purchase of new equipment. By the end of stage three there is a detailed design of the new organisation of production or service.

Figure 1 The systems life cycle



Life Cycle Stage	Management	Union/Worker
1. Feasibility Study Initial Investigation	Senior Management & Consultants	
2. Conceptual Design	Management & Consultants	Individual Workers
3. Detailed Design	Consultants	
4. Implementation	Everybody	Everbody

The fourth stage consists of implementation. At this stage, management must seek some worker involvement and cooperation in order to train users and schedule the introduction of the new system into the workplace. By then, most of the major decisions have been made and negotiations on impact and alternative design are necessarily quite limited. Often, discussions are confined to superficial effects such as input screens or colours for new offices and equipment, while massive changes have taken place in the work organisation and environment.

Critique of traditional design method

This method of introducing new technology and work organisation is generally viewed unfavourably by organised labour and by workers as it relegates union and worker involvement to token participation at the final stage, long after the system has been almost completely designed and constructed.

In defending this traditional method, analysts argue that workers are often interviewed in the first and second stages and are therefore able to influence the design at these early stages. However, these interviews are rigidly structured, one-way, information-gathering sessions with the analyst finding out from the worker as much as possible about current work methods. An interrogation, no matter how pleasantly conducted, is not a substitute for real participation.

This is a flawed method of design, not just from the worker or union perspective, but also from a social point of view—even, one might suggest, from a designer's viewpoint. A major problem with this method is that the costs of significant changes grow exponentially with time. End users, who are often the most 'expert' sources about their work and needs, are not involved in decision-making until most of the design decisions have already been made.

Let us look at a very simple example, that of designing a building for access by the disabled to see how the stage of 'user' involvement can be crucial to an inexpensive design. Until very recently, most buildings were constructed with no consideration for the disabled. Through lawsuits and political pressure, some buildings were renovated to make them accessible. In all instances, these renovations were more expensive and took longer to complete than if they had been incorporated in the initial plan.

Worker involvement in systems development

Even the most conservative systems designers, using the traditional systems life cycle, recognised that end users must be 'interviewed' for their knowledge. But operations-level expertise cannot usually be acquired by simply interviewing a 'subject'. Obviously, workers who do a particular type of work for seven or eight hours a day have a different understanding, perspective and knowledge of the intricacies of their job than someone who watches, studies or supervises them. The real positive potential of new technology is the opportunity to incorporate the knowledge and experience of workers into new designs and work organisation that has the potential to both increase production as well as improve the quality of working life. But it is highly unlikely that the quality of working life will ever become a major design criterion unless the workers themselves are part of the decision-making process in the design of new technology.

A further reason for seeking worker involvement in new technology is that much of the productivity gains possible with this new technology will be from promoting its flexibility. This will require the creation of a new type of workplace, where workers are part of the development process—participants in development, rather than simply end users of rigid systems.

Larry Hirschhorn argues that tacit, shop-floor knowledge will increasingly need to be incorporated in the design of new technology systems:

> Since the beginnings of the scientific management movement, engineers, designers, and managers have tried to codify knowledge in explicit procedures, routines, and machine designs; they have also tried to separate doing and knowing by limiting the knowledge and planning competence of shop floor workers. A critical gap has emerged between the tacit, experiential knowledge that comes from shop floor experience and the theoretical knowledge of machine fundamentals. This division has limited the development of flexible automation systems, for the design and integration of control systems require extremely detailed knowledge of the specific dynamics of a particular machine system, not just of machines in general. As one industrial psychologist notes, 'The operator can achieve better results than the engineer. This can probably be put down to his ability, derived from intimate experience of the plant, to take into account the many ill-understood factors which affect the plant's running but which he cannot communicate to the engineer'. The tension between learning and control is now evident in the politics or work design. (Hirschhorn 1984, p. 58)

Hirschhorn's argument for worker involvement in systems development is based on his appreciation of the 'skill' that workers acquire from doing a job. While experience and knowledge of work routines are aspects of 'skill', rather like technology itself, skill is a socially mediated product.

The social mediation of skills

When we use the term skill, most people think of an objective, measurable body of knowledge about work and work routines. But skill is more than job knowledge. It also implies job autonomy measured by the range of tasks and the discretion exercised over these tasks. If we define skill as both job knowledge and job autonomy, then clearly it is very difficult to discuss skill independent of the organisation of work.

In debates about the educational implications of information technology, many disputes have revolved around whether or not this new technology will lead to an increase or decrease in workers' skills. Clearly, it could lead to both or either, depending on how work is restructured and reorganised in the workplace over the next few years. Information technology has made possible to a new work organisation which could greatly increase workers' skills, defined both as knowledge and autonomy. If grafted onto the Fordist production model of the assembly line, however, it will simply be one more instrument for the control and deskilling of workers.

At this point in the information revolution, we are only beginning to develop new methods of work organisation. We are at the convergence stage in an organisational revolution. It is far from determined which new organisational models will be adopted. As a useful analogy to assist us in understanding the stages that major changes in technology go through, it is instructive to look at the first administrative revolution in office work to see how over a period of some fifty years the mechanical office developed.

Stages in an administrative revolution

There were essentially three phases in the last administrative revolution in the office: stage one, the introduction of new tools and machinery within the old system of work organisation; stage two, convergence of the new equipment into a new method of work organisation and office division of labour; and stage three, consolidation of the new work organisation.

The first period, from the late 1860s until the turn of the century, saw the introduction of a fascinating variety of office machinery: the typewriter, the telephone, tabulators, accumulators, accounting machines and teletypes. In most instances, this equipment was introduced as a mechanical assistant to one aspect or task in a clerk's job.

In the second stage, called convergence, new work organisation methods were developed to compliment the use of the mechanical equipment. With significant growth in businesses and increasing demand for greater administrative coordination, employers sought to rationalise office administration with new work methods and procedures in order to keep costs down and to assert maximum control over the growing administrative workforce. This rationalisation of the office included a major restructuring of the organisation of office work. The new work methods divided clerical work into separate tasks, creating new dedicated (deskilled) positions. A copy clerk was created and assigned the sole task of copying letters. It then became profitable as well as practical to introduce equipment to help mechanise this new job. The copy clerk was given a writing machine, the typewriter. In the early years, the typist was so closely identified with the technology that both the machine and operator were called 'typewriters'. Another part of office administrative rationalisation included the replacement of some male clerks by female workers. As long as the clerk's position was seen as an apprenticeship for becoming a businessman, owner or boss, it was inconceivable that a woman would hold such a position. But in the newly reorganised offices, women could hold new, deskilled positions (e.g. typewriters and copy clerks) as long as it was clear that they could not advance to managerial positions. Few male clerks objected to the mechanisation of the lowest jobs in the office.

In the final stage, consolidation, the new work method of dividing clerical functions into specific tasks became generalised. The office came to mirror the factory in segmented work organisation. Scientific management entered the office and clerical jobs were divided into dedicated, deskilled, isolated departments. In the accounting office, there were payroll clerks, accounts receivable clerks and accounts payable clerks. Few clerical workers followed a job through from beginning to end. Instead, their work consisted of a Fordist production model of contributing one more step in a multi-step process. Once consolidated, the mechanical office of the 1920s remained a dominant model of work organisation until as late as the early 1970s. Organisationally, the office of the 1970s would have been quite familiar to clerical workers from the 1920s.

From the mechanical office to the paperless office

If we look at the changes which are taking place in the office today as we replace the 'mechanical office' and move toward the new 'electronic office', we can trace the same stages in the development discussed in the rise of the mechanical office. On the move toward the 'paperless office', we have clearly passed the first stage, introduction of machines in isolation. This was the period of the 1960s and 1970s when many offices introduced microelectronic equipment. Underlying the concept of new tools or machines introduced in isolation, many of the systems introduced into the office at this time were referred to as 'stand-alone' systems. Some of the equipment entering the office at this time was: word processors, electronic data processing equipment, databases, accounting systems, telecommunications and facsimile reproduction equipment. Word processors were seen as powerful, smart typewriters. Electronic data processing was seen as an electronic filing cabinet. Telecommunication was viewed as an enhanced telephone service. In this first stage, the new equipment was essentially incorporated into the existing method of production and processing, possibly leading to a slight productivity gain or increased accuracy or access to information.

The second stage, convergence, is where we are today. The real integrated potential of the new machines, which were first introduced in isolation, is sought through attempting to link these machines into new systems. No-one wants a stand-alone system, compatibility is now the watchword. In office automation this stage is characterised by the search for 'networking' capabilities which will permit information to be easily and accurately transferred and shared by a wide variety of equipment. Sometimes referred to as the 'paperless office', an evolving new work organisation is appearing which assumes that information will be 'captured' as close to the source as possible. Once entered into the system, the information will never again have to be re-entered, eliminating the endless repetition, duplication and error associated with paper-based systems.

The 'paperless office' is not yet a reality, but the various changes in work organisation which we are seeing today are part of the move toward a very different labour method in information processing. Although we have passed the stage of introduction of new equipment in isolation and have already begun the stage of convergence, we are still not at the stage of consolidation. This means that it is an ideal time for proposing alternative models to work organisation.

Labour transforming technology transforming labour

While many of us recognise the need for participation in choices and decision-making with regard to technology, this challenge comes at a time when most of us are under tremendous pressure. New technology has already contributed significantly to the disciplining of organised labour and many of us feel powerless in the face of the massive changes. The general mystification of technology in our society contributes to our feeling of powerlessness.

Technology is and will continue to transform the workplace. Here, more effectively than anywhere else, workers have an opportunity to play a major role in determining the outcome of change. There is a tremendous opportunity for workers and other groups in society to begin to construct alternative, liberating models of work and life. It is essential for the entire community that workers—the experts in the workplace—provide an alternative vision of how society can produce goods and services, minimise waste and maximise the quality of both worklife and what is produced.

A first step in constructing an alternative vision is to learn to analyse critically and evaluate socially mediated processes such as technology and skill. The industrial revolution made literacy an important tool for the entire workforce. In the 'information age', an additional type of literacy will be required: the ability to understand and think critically and imaginatively about technology.

There is a slogan in the computing industry that, 'the best way to predict the future is to create it'. There is an unprecedented opportunity today to begin to create a new future for all of us in the workplace. We are still living in 'interesting times' when major changes can and will take place.

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READINGS

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EDUCATIONAL IMPLICATIONS OF HIGH TECHNOLOGY

H.M. LEVIN & R.W. RUMBERGER

H.M. Levin & R.W. Rumberger, *Educational Implications of High Technology*, Institute for Research on Educational Finance and Governance, Stanford University, Paulo Alto, Calif., 1983.

New advances in technology--in genetic engineering, in robotics, and particularly in computers--are transforming the lives of Americans in the home and the workplace. While the micro-computer has signalled the arrival of "high-technology" in the home, many observers believe that its influence in the workplace will be even more profound. Not only do industries producing micro-processors, robots, and the fruits of bio-technology promise rapid growth in sales and employment, but micro-computers and robots are also expected to transform other industries and occupations throughout the economy. One observer predicted that 40 to 50 percent of all American workers will be using electronic terminals by 1990 (Giuliano 1982, p. 152).

Government leaders, Republican and Democrat alike, see the growth of high-technology as one key to solving America's current economic problems. As President Reagan said in his State of the Union Address on January 25, 1982:

> ...as surely as Americans' pioneer spirit made us the industrial giant of the 20th century, the same pioneer spirit today is opening up another vast frontier of opportunity--the frontier of high technology. In conquering this frontier, we cannot write off our traditional industries, but must develop the skills and industries that will make us a pioneer of tomorrow.

Business leaders have echoed this sentiment, calling on the educational system to make the changes necessary to provide enough skilled workers to fuel the growth of high technology. As Steven Jobs, co-founder of Apple Computer, recently stated in a speech at Stanford University: "A massive retraining effort by government and private industry could alleviate the problem of job skill obsolescence created by the expanding computer industry" (Stanford Daily 1983).

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Policymakers have proposed vast changes in the educational system to respond to these challenges. The proposed changes are based on the belief that our high-technology future will require workers with more sophisticated job skills. A recent publication from the Education Commission of the States (1982) exemplifies this widespread belief:

> Occupational growth throughout the 1980s is projected to expand most rapidly in the higher-skilled, technical occupations. Tomorrow's workers will likely need improved skills in the selection and communication of information. Many of today's skills considered to be of a "higher" level are the potential basic skills of tomorrow (p. 1).

Such beliefs have prompted proposals to upgrade math and science education in our nation's secondary schools, to place computers in all elementary and secondary schools, and to generate $1 billion in new support for high-technology education (Botkin, Dimancescu, and Stata, 1983).

These beliefs are based on two assumptions. First, future job growth in the United States will favor professional and technical level jobs--such as engineers and computer programmers--that require considerable education and sophisticated training in computer-related areas. Second, high technology will upgrade the skill requirements of existing jobs because workers in those jobs will work increasingly with technologically sophisticated equipment, such as computers.

Despite the widespread propagation of these assumptions, both are contradicted by available evidence. Most new jobs will not be in high technology occupations, nor will the application of high technology in existing jobs require a vast upgrading of the skills of the American labor force. To the contrary, the expansion of the lowest skilled jobs in the American economy will vastly outstrip the growth of high technology ones. And the proliferation of high technology industries and their products is far more likely to reduce the skill requirements for jobs in the U.S. economy than to upgrade them.

In the remainder of this paper we will examine the two common assumptions about high technology and the supporting evidence in greater detail. We will then discuss the educational implications of our high-technology future.

Future Employment Growth

To what degree will high technology jobs dominate future employment growth? Accurate predictions on the composition of future employment depend on the analysis of many factors. These include such influences as economic growth, labor force demography, foreign trade movements (many of which are influenced by changes in international exchange rates), technological breakthroughs, and decisions of multi-national organizations with respect to the international rationalization of production. Many of these factors are difficult to predict because they are subject to political and economic vagaries on a world scale.

While no methodology is likely to provide completely accurate results, those that consider a large number of pertinent influences are likely to be superior to simple extrapolations or other uncomplicated projections. In this respect, the estimates of the Bureau of Labor Statistics (BLS) of the U. S. Department of Labor represent some of the most refined attempts to project the growth and composition of future employment.

Since the 1960s BLS has periodically conducted a series of projection studies based on an economic growth model. Over the last two decades "the methodology has been continually modified to include greater industrial detail, other models, more rigorous analytical techniques, a more automatic system for processing calculations, and broader coverage including labor force and occupations in the current version" (Oliver 1982, p. 1). The methodology incorporates several assumptions about growth in the labor force, economic output, and productivity. Further, to allow for uncertainty, recent projections--for the year 1990--are based on three different scenarios regarding the growth of these various factors. The more optimistic projections assume high growth rates in economic output and productivity, while the more conservative projections assume lower growth rates.

The employment projections are based on occupational employment patterns within detailed industries in 1978, projected employment patterns within these industries in 1990, and projected total employment within each industry based on the economic projections. It is important to note that employment growth refers only to new jobs added to the economy rather than job openings. Job openings will be much higher. BLS estimates that employment growth will account for only one-third of total job openings between 1978 and 1990 (excluding openings due to workers' changing jobs), with the remaining two-thirds due to the replacement of workers in existing jobs who withdraw from the labor force because of death, retirement, or other reasons (U.S. Bureau of Labor Statistics 1980, p. 6).

We will limit our discussion to employment growth resulting from projected creation of new jobs using the BLS figures based on assumptions of modest growth rates. According to these figures, employment will increase by 22 million or 23 percent between 1978 and 1990 (Table 1). The fastest growing job categories in relative terms--percentage change between 1978 and 1990--include several high technology areas. This projected expansion apparently has led to the commonplace assumption that aggregate job growth will be biased toward high technology occupations. Of the five fastest growing occupations, three--data processing machine mechanics, computer systems analysts, and computer operators--deal with high-technology products. Employment in these five occupations is projected to increase by over 100 percent, more than four times the employment growth rate in all occupations.

Such percentage changes are misleading, however. The total number of new jobs generated in these and other high technology occupations will be vastly outweighed by employment growth in other areas. Slower-growing occupations with a large employment base are expected to contribute far more jobs to the economy than high technology occupations. Of the 20 occupations expected to generate the most jobs in the economy during this period, not one is related to high technology. As Table 1 shows, the five occupations expected to produce the most new jobs are all in low skilled areas: janitors, nurses' aides, sales clerks, cashiers, and waiters and waitresses. These five jobs alone will account for 13 percent of the total employment growth between 1978 and 1990. Only 3 or 4 of the "top 20" occupations in terms of total contribution to job growth require education beyond the secondary level, and only two require a college degree (teaching and nursing).

This picture is further reinforced by examination of individual high technology job categories. While jobs for computer systems analysts will increase by over 100 percent between 1978 and 1990, only 200,000 new jobs will be created. In contrast, there will be over 600,000 new jobs for janitors and sextons. In fact, more new jobs for janitors will be created than new jobs in all the five occupations with the highest relative growth rates. Consider another example: about 150,000 new jobs for computer programmers are expected to emerge during this 12 year period, a level of growth vastly outpaced by the 800,000 new jobs expected for fast food workers and kitchen helpers.

Employment growth for the economy as a whole will favor low and middle level occupations. While employment in professional and technical occupations is expected to increase by 20 percent for the twelve year period, this growth rate is lower than in either of the two preceding decades (Table 2). Employment in all professional and managerial occupations increased by 36 percent between 1960 and 1970, and 45 percent between 1970 and 1980. But it is projected to increase by only 28 percent between 1978 and 1990. Clerical and service occupations will account for 40 percent of the employment growth during this period.

Revised BLS estimates show that high technology occupations, as a group, will account for only 7 percent of all new jobs between 1980 and 1990 (Coleman 1982). BLS forecasts are further supported by other government analyses, such as those by the Department of Defense (Choate 1983).

In summary, government estimates suggest that employment growth will favor jobs that require little or no training beyond the high school level. Although employment in high technology occupations will increase quickly in percentage terms over this decade, the contribution of these jobs to total employment growth will be quite small.

The Impact of Technology on Existing Jobs

While the growth of high technology occupations will not have a major impact on overall employment growth in the foreseeable future, high technology will have a profound impact on many jobs in the economy. Increasingly workers in a variety of work settings will find their jobs altered by sophisticated computer technologies. Secretaries will work with word processing equipment; bookkeepers will use computerized, financial spread sheets; clerical workers in purchasing and inventory will apply their skills to automated and computerized record systems; mechanics will use diagnostic equipment employing mini-computers; and telephone operators will rely on computerized directories. But will the use of these new technologies require workers with more sophisticated skills?

To answer this question, it is necessary to examine how technology is applied in the workplace. The application of technology is part of a more fundamental process that has characterized production historically--the process of dividing work tasks into simplified operations that require few skills to perform. Through this process production tasks are fragmented into repetitive and routinized activities for which unskilled and low paid workers can be employed. This movement toward a minute division of labor was first advocated by Adam Smith in The Wealth of Nations and later refined by Charles Babbage:

> Babbage's principle is fundamental to the evolution of the division of labor...it gives expression not to a technical aspect of the division of labor, but to its social aspect. Insofar as the labor process may be dissociated, it may be separated into elements some of which are simpler than others and each of which is simpler than the whole. Translated into

> market terms, this means that the labor power capable of performing the process may be purchased more cheaply as dissociated elements than as a capacity integrated in a single worker. Applied first to the handicrafts and then to the mechanical crafts, Babbage's principle eventually becomes the underlying force governing all forms of work ...no matter in what setting or at what hierarchical level (Braverman 1974, pp. 81-82).

Technology aids this process. The division of work tasks into component parts is often accompanied by the mechanization of some of those tasks. For example, the assembly line adopted by Henry Ford early in this century, although first controlled by nonmechanical methods, was soon mechanized (Gartman 1979, p. 200). As technology advances, an increasing number of work tasks can be mechanized. Advances in micro-electronics, in particular, threaten to further fragment work tasks and contribute to the "deskilling" of jobs (Cooley 1983).

The process of fragmentation not only allows employers to lower their costs, but to better control the production process. The organization of work in the United States has evolved from many small, local units into a much smaller number of large, hierarchical, national and international organizations. This transformation has been accompanied by more sophisticated methods of control (Marglin 1974; Edwards 1979).

Technology also aids efforts to control the workplace:

> Machinery offers to management the opportunity to do by wholly mechanized means that which it had previously attempted to do by organization and disciplinary means. The fact that many machines may be paced and controlled according to centralized decisions, and that these controls may thus be in the hands of management, removed from the site of production to the office--these technical possibilities are of just as great interest to management as the fact that the machine multiplies the productivity of labor (Braverman 1974, p. 195).

In the case of the automotive assembly line, for example, mechanization not only reduced labor costs but allowed management to more easily control the pace of production (Gartman 1979).

It is often asserted that while machines will increasingly perform tasks previously performed by workers, generally the machines will perform the most tedious and least skilled tasks. That is, the most desirable and challenging tasks will continue to be performed by workers. Further, as automation becomes more widespread, with more and more workers using complex, sophisticated machines, workers will need increasingly complex skills to work with them.

James Bright, a professor at the Harvard Business School, investigated similar claims more than 20 years ago. He examined the effects of automation on job skill requirements in a variety of U.S. manufacturing firms. The general assumption, which was as common then as today, was that increasing levels of automation required increasing skills by operators and other production workers (Figure 1). Bright observed, however, that the skill requirements of jobs first increased and then decreased sharply as the degree of mechanization increased:

> ...there was more evidence that automation has reduced the skill requirements of the operating work force, and occasionally of the entire factory force including the maintenance organization...automated machinery tends to require less operator skill after certain levels of mechanization are achieved. It seems that the average worker will master different jobs more quickly and easily in the use of highly automatic machinery. Many so-called key skilled jobs, currently requiring long experience and training, will be reduced to easily learned, machine-tending jobs (Bright 1958, pp. 86-87).

Evidence for the United States as a whole supports Bright's conclusions: aggregate skill requirements of jobs in the U.S. economy have changed very little over the last two decades despite widespread automation in many industries (Rumberger 1981).

Case studies that have documented the application of more recent technologies in a broad variety of work settings confirm this tendency (Zimbalist 1979a). For example, many of the jobs in the printing industry, such as typesetting, press operating, and photoengraving, historically have required highly complex craft skills (Zimbalist 1979b). A series of technological advances over the last 30 years has enabled many of these operations to be performed by machines. The introduction of teletypesetting machines in the 1950s took over many manual typesetting operations. Then the introduction of computer-aided phototypesetting in the 1960s took over the tasks of word hyphenation and line justification. Finally the introduction of video display terminals removed the tasks of composing from the press floor altogether (Zimbalist 1979b, pp. 107-109). These advances reduced sharply the skill levels of workers who remained in the newspaper composing room.

The computer industry itself, the heart of the high technology revolution, provides another case. Early computers were not only large and expensive by today's standards, but they required programmers and operators with fairly complex skills to use them (Kraft 1977; Greenbaum 1979). But as the technology changed, so did the tasks and the skills involved in their operation. Computer programming was soon divided into the more creative, skilled tasks--performed by computer systems analysts--and the more tedious, routine tasks--performed by computer programers and coders. Programming itself became easier as computer languages evolved from high-level machine languages to packaged programs to more "user-friendly", menu-prompted packages (Kraft 1977).

Advances made in computer software have meant that workers can use computers in a wide variety of work settings without any knowledge of computer languages. The new generation of office computers, for example, are specifically designed so that "no special computer skills are needed to operate" them (Giuliano 1982, p. 149). Moreover, office computers perform many of the tasks formerly done by secretaries, actually reducing the requisite skills of office work (Glenn and Feldberg 1979). Word processors can correct typing errors automatically by use of electronic dictionaries, so letter-perfect typing and strong spelling skills are no longer required. In addition, supervisors can monitor each operator's output and compare productivity among workers instantaneously (Glenn and Feldberg 1979; Arnold, Birke, and Faulkner 1981).

Computers and other products of the micro-electronics revolution are transforming work in virtually all sectors of the economy, from agriculture to transportation to engineering design (Scientific American 1982). The future suggests that this transformation will become even more widespread and that technologies will become increasingly sophisticated. Machines will be able to perform more complex, mental tasks as more advanced software is developed. But the use of such sophisticated equipment will not necessarily require workers with more sophisticated skills. In fact, past technological advances suggest the opposite is often the case. The automobile of today is far more sophisticated than its predecessor of fifty years ago. Yet, today's car is far easier to drive. Computers are far more sophisticated today than they were 10 or 20 years ago. But programming and using computers are considerably less demanding today, and many computer-related jobs require virtually no knowledge of computers.

A related concern is that entire classes of skilled workers will disappear or will be severely reduced in numbers as their jobs are replaced by robots or computer software. For example, robots could replace up to 3 million operative jobs in the next 20 years and potentially eliminate all 8 million operative positions--currently 8 percent of the workforce--by the year 2025 (Ayres and Miller 1982, p. 42). The widespread use of computer-aided design (CAD) may virtually eliminate the occupation of drafter in the not-too-distant future, a potential loss of 300,000 skilled positions (Gunn 1982). The potential of high technology to displace jobs more generally is ominous (Leontief 1982).

It is clear that applications of high technology can be used to enhance the quality of working life and the utilization of worker skills, or to reduce them (Walton 1982). The outcome will depend on how the technologies are applied and how employers use them. Past applications of technology in the workplace as well as present evidence suggest that future technologies will further simplify and routinize work tasks and reduce opportunities for worker individuality and judgement. Moreover, the displacement in jobs and the downgrading of skill requirements for most of the new positions will undermine employment generally, and especially the employment of skilled workers.

Educational Implications

Given the widely, advertised view that high technology will dominate the demand for new workers and raise skill requirements of jobs, the usual prescription is that there must be a vast transformation of the educational system. It is assumed that rising skill levels for employment will require more training in mathematics, computer science, and technical applications for the labor force as a whole as well as an increasing number of workers with specialized training in these fields. Consequently, schools must adapt to these new responsibilities through major upgrading of mathematics and science curricula as well as teacher preparation. Schools also need to establish specialized courses of study in computer applications and programming to provide vocational training for high school and community college students.

We have asserted, however, that while some jobs will require these skills, the vast majority will not. Indeed, one of the major purposes and effects of high technology is to simplify or reduce the skill requirements for performing a particular work task. With the exception of a relatively small number of highly specialized positions for designing and implementing high technology applications, most jobs will not require higher skill levels. Industrial shifts and technological change may require different skills, but the preponderance of persons affected by such shifts will not need more mathematics or computer science. And, for significant numbers of jobs, the skill requirements that will have to be met will be less-demanding.

Based upon these assessments, what educational policies are implied?

First, the general educational requirements for creating good citizens and productive workers are not likely to be altered significantly by high technology. Everyone should acquire strong analytic, expressive, communicative, and computational skills as well as extensive knowledge of political, economic, social, and cultural institutions. These aptitudes and knowledge are required for understanding daily experiences and for ensuring access to social opportunities. To the degree that the present schools fall short of providing these results, they should be sought for their own sake rather than because of the claim that they are required for a high technology future.

Second, since we cannot predict in any precise sense which jobs will be available to particular persons, which jobs they will select from among those available, and what the characteristics of jobs will be over a forty year working life, it is best to provide students with a strong general education and an ability to adapt to a changing work environment. Such adaptation requires a sufficient store of information about culture, language, society and technology as well as the ability to apply that information and acquire new knowledge. Accordingly, general academic and vocational preparation should be stressed, as opposed to specific training, especially for young students.

Specific job skills can best be learned on the job, if a worker's general background is sufficient (Thurow 1975). Recent surveys of both U.S. and British employers indicate that they seek new employees with a sound education and good work habits rather than narrow vocational skills (Maguire and Ashton 1981; Wilms 1983).

Third, if changes in work requirements arise abruptly and change occurs at a faster rate than previously, the educational system may need to respond more quickly and efficiently to training needs. It may require better ties with industry and should not exclude the possibility of more industry-based training activities. It should also be tied to a system of recurrent education, since workers will no longer be able to acquire a set of job skills at the beginning of their careers that will be useful over their entire work lives (Levin and Schutze 1983; Mushkin 1974).

In summary, the educational implications of high technology are that a solid basic education rather than narrow vocational preparation will become more important in the future. This will require elementary and secondary schools to strengthen virtually all their instructional offerings that require analytical and communicative skills.

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Table 1

Employment and Employment Growth in the Fastest Growing Occupations: 1978-90

Occupations	Employment (thousands)		Employment Growth 1978-90		
				Number of Jobs	
	1978	1990	Percentage Increase	(thousands)	(percent of all occupations)
Fastest relative growth[a]					
1. Data processing machine mechanics	63	156	148	93	0.4
2. Paralegal	28	66	132	38	0.2
3. Computer systems analysts	185	384	108	199	0.9
4. Computer operators	169	317	88	148	0.7
5. Office machine and cash register servicers	49	89	81	40	0.2
Total	494	1012	105	518	2.4
Fastest absolute growth[b]					
1. Janitors and sextons	2585	3257	26	672	3.1
2. Nurses' aides and orderlies	1089	1683	55	594	2.7
3. Sales clerks	2771	3362	21	591	2.7
4. Cashiers	1501	2046	36	545	2.5
5. Waiters/Waitresses	1539	2071	35	532	2.4
Total	9485	12419	31	2934	13.3
Total, all occupations	97610	119590	23	21980	100.0

[a] Based on the percentage increase in the number of jobs created

[b] Based on the number of jobs created

Source: Carey (1981), Table 2

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Table 2

Employment Growth by Major Occupation Group:

1960-90

Major Occupation Group	Employment Growth (percentage distribution) 1960-70 (1)	1970-80 (2)	1978-90 (3)
Professional and technical	30.0	22.3	20.3
Managerial	6.0	22.7	7.7
Sales	5.8	2.6	7.0
Clerical	32.9	21.0	20.0
Crafts	11.2	9.5	12.2
Operatives	7.5	1.8	10.0
Laborers	.7	4.8	4.8
Farm workers	-14.5	- .2	- 2.6
Service	20.4	15.5	20.7
Total	100.0	100.0	100.0

Sources: (1)-(2) Rumberger (1984), Table 2; (3) Carey (1981), Table 2

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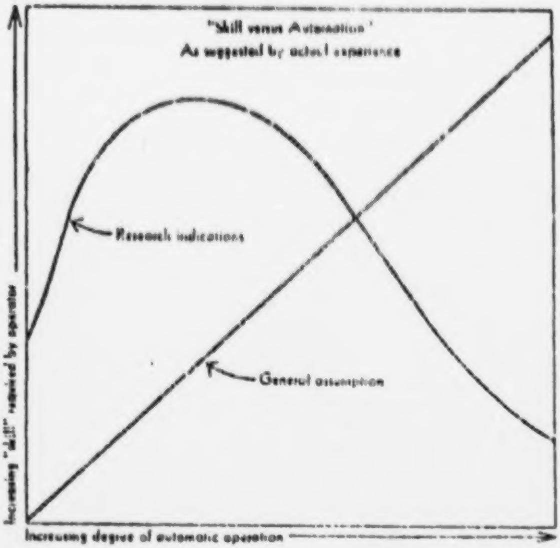
Figure 1

The Relationship Between Increasing Levels of Automation and Job Skill Requirements



Source: Bright (1966), p. II-209.

2

OFFICE TECHNOLOGY AS EXILE AND INTEGRATION

S. ZUBOFF

S. Zuboff, *In the Age of the Smart Machine: The Future of Work and Power*, Heinemann, Oxford, 1988, pp. 124–73.

> **I always deemed him the victim of two evil powers—ambition and indigestion. The ambition was evinced by a certain impatience of the duties of a mere copyist, an unwarrantable usurpation of strictly professional affairs. . . . The indigestion seemed betokened . . . especially by a continual discontent with the height of the table where he worked. . . . He put chips under it, blocks of various sorts, bits of pasteboard, and at last went so far as to attempt an exquisite adjustment, by final pieces of folded blotting-paper. . . . If, for the sake of easing his back, he brought the table-lid at a sharp angle well up toward his chin, and wrote there like a man using the steep roof of a Dutch house for his desk, then he declared that it stopped the circulation in his arms. If now he lowered the table to his waistbands, and stooped over it in writing, then there was a sore aching in his back. . . . If he wanted anything, it was to be rid of a scrivener's table altogether.**
>
> **—Herman Melville**
> ***Bartleby the Scrivener***

AUTOMATING AND INFORMATING THE WHITE-COLLAR WORKPLACE

For the millions of people who work in or have occasion to visit corporate facilities, the on-line office has become a familiar, even a clichéd, image. There are the clusters of desks, usually separated by partitions, and each is home to a video display terminal. The office may be softly lit; some even have a smattering of potted palms or rubber plants. A quick glance can give the impression that the women and men who work in these offices have been mesmerized by the green or amber glow of their video screens, as they spend the better part of each day with attention fixed on luminous electronic numbers and letters.

In 1982 I began a series of visits to one such office. After a strenuous and sometimes chaotic conversion from "paper-and-pencil" processing to an on-line computer system, production had just begun to reach the level expected from the investment in new technology. The rows of desks and paper clutter had given way to clean surfaces and desktop terminals. The work stations were separated by tall partitions, which created a cubicle effect around the work space of each clerk.

One afternoon, after several weeks of participant observation and discussions with clerks and supervisors, I was returning to the office from a lunch with a group of employees when two of them beckoned me over to their desks, indicating that they had something to show me. They seated themselves at their workstations on either side of a tall gray partition Then they pointed out a small rupture in the orderly, high-tech appearance of their work space: the metal seam in the partition that separated their desks had been pried open.

With the look of mischievous co-conspirators, they confided that they had inflicted this surgery upon the wall between them. Why? The small opening now made it possible to peek through and see if the other worker was at her seat, without having to stand up and peer over or around the wall. Through that aperture questions could be asked, advice could be given, and dinner menus could be planned. At the time I took this to be the effort of two women to humanize their surroundings. While I still believe that is true, the weeks, months, and years that followed led me to a fuller appreciation of the significance of their action.

Installing those partitions was the final step that completed the clerks' relegation to the realm of the machine. Exiled from the interpersonal world of office routines, each clerk became isolated and solitary. That interpersonal world involves the work of managing; it is the domain in which coordination and communication occur. These clerks not only had been denied benign forms of social intercourse but also had been expelled from the managerial world of *acting-with* that had formerly required them to accept, in some small degree, responsibility for the coordination of their office. Installing the partitions was one concrete technique, among others, designed to create the discontinuity needed to achieve Leffingwell's goal: to convert the clerk from an interpersonal operator to a laboring body, substituting communicative and coordinative responsibilities with the physical demands of continuous production.

The first sections of this chapter will describe how information technology is being used in the service of Leffingwell's goals and the consequences that the simplification, isolation, and computer-mediation of clerical work has had for the psychological experience of office work and the forms of knowledge that it implies. The era of computerization has already produced several compelling studies of the industrialization of office work and its effects on clerical workers.[1] It is necessary to understand these effects in the context of the historical trajectory of clerical work (that is, its managerial heritage, the transition from an emphasis on *acting-with* to *acting-on*) and in relation to the managerial choices that will determine the future configuration of the clerical occupation.

The story of automation in the office does not end with Leffingwell's vision. Because information technology has a voice; because it has the power to convert events and processes to a symbolic medium and make them visible in a new way; because, in a word, this technology informates as well as automates, its consequences for the office are more complex than the principles of scientific management can account for. The second half of this chapter will explore how the informating power of the technology may increase the intellective demands of work, not only for clerks, but for managers and professionals as well, even as it encroaches upon the traditional action-centered skills that have undergirded the managerial process. In many cases, organizational functions, events, and processes have been so extensively informated—converted into and displayed as information—that the technology can be said to have "textualized" the organizational environment. In this context, the electronic text becomes a new medium in which events are both observed and enacted. As an automating technology, computerization can intensify the clerk's exile from the coordinative sphere of the managerial process. As an informating technology, on the other hand, it can provide the occasion for a reintegration of the clerical role with its managerial past and for a reinvigoration of the knowledge demands associated with the middle-management function.

Information Technology in Two Offices

For many office organizations, the first years of the 1980s were a time of transition from the assembly-line paper factories of earlier decades to computer systems that allow clerks to accomplish all aspects of a transaction in an "on-line" mode. This means that when a transaction is completed, the clerk presses the key marked ENTER, the transaction is recorded instantly in the central computer, and appropriate follow-up functions (for example, checks mailed, accounts debited or credited, et cetera) are set into motion.

The dental claims operation in Consolidated Underwriters Insurance's suburban Massachusetts office represents its most ambitious effort to convert from a paper-based to a computer-based office environment. According to senior executives, costly automation projects in the 1970s had generated a new determination to use advanced information technology to achieve "a more attractive price/value relationship in customer services." Claim service was a top priority. The new automated claims system was designed in-house during 1980 and installed in one suburban claim office in 1981. The office was composed of sixty-five benefits analysts who were predominantly young women earning a second income for their families. The conversion process occurred over an eight-month period in 1981. By 1982, when I first visited this office, productivity increases of 30 to 40 percent already had been achieved.[2]

In the old environment, a benefits analyst began the day by collecting claims in the mail room. She next went to the file area to pull the ledgers corresponding to each account and then to check the customer data in the files against the data on the claim forms. Taking the claims and ledgers to her desk, the benefits analyst checked contract limitations and any other arrangements pertinent to the account, completed the necessary paperwork, updated the ledger, and then finished the day by refiling ledgers, after having sent the claim to a check-processing unit. During the course of completing a claim, a benefits analyst might consult with her supervisor or with other benefits analysts for opinions about different dental procedures, how to handle a specific set of arrangements, or where to find necessary documentation. Benefits analysts were often hired on the basis of prior knowledge of dental procedures, as such information proved to be a useful resource for the judgments required by the claims process.

With the new on-line system, the procedure changed significantly. Benefits analysts still began their day in the mail room rounding up claims for processing, but the ledgers had disappeared. Instead, the analysts logged onto their computer terminals, called up the account in question, and processed the claim by entering data into the machine. Once the ENTER key was pressed at the completion of the claim, a check would be issued to the customer.

Several hundred miles away in suburban Pennsylvania, the corporate offices of Universal Technology housed a back office operation called Stock and Bond Transfer. The office was composed of approximately seventy transfer assistants and data-entry clerks, predominantly middle-aged women, who completed the transactions associated with the transfer of shareholder stock certificates. Such transfers might be initiated because of marriage, death, gift-giving, or a variety of other reasons.

In the old environment, the transaction had been shared by two different employees. First, the transfer assistant received the paperwork associated with a transfer. She checked to see if transfer requirements, which included the shareholder's endorsement, guarantees, and legal documentation, were fulfilled. When the transfer assistant had completed the necessary paperwork, she delivered her cases to a data-entry clerk, who inputted the transfer data into the computer system. The transfers were processed in batches by the system at the close of the day. In this office, the position of the transfer assistant was considered part of management, albeit at the lowest stratum in the managerial pyramid, while the data-entry position was nonmanagement and explicitly referred to as "clerical."

A new system that made it possible to process an entire transfer online was installed in 1981. The transfer assistants absorbed the data-entry function, although their positions retained the formal designation as "managerial." The data-entry clerks were upgraded to become full-fledged transfer assistants. With the new computer system, work was automatically routed to a transfer assistant, though she would still receive print copies of the legal documents associated with the transfer case. The system was carefully formatted, so that each stage of the transfer procedure was accomplished in interaction with the machine. The input procedure was preformatted and simplified. The system would not proceed to the next stage of the transaction if it detected errors in the information already entered. With the installation of the new system, the transfer assistants spent approximately 70 percent of their time interacting with their machines, while the remainder of their time was spent reading procedural revisions, references, and incoming investor-generated material; talking to shareholders over the telephone; or preparing written forms and letters in response to shareholder inquiries. The goals of the conversion were to create "a continuous production environment," to achieve standards of 98 percent accuracy, and to increase productivity. Most managers agreed that these goals generally had been met. One-and-a-half years after the conversion, the work force had been reduced by almost 20 percent. (Those employees had been transferred to another part of the back office.)

The responses of these two groups to computerization was remarkably similar, as were the dilemmas associated with the changing skill demands in each office. There were also some important differences. The sections that follow will show how the automation of dental claims pushed the job of the benefits analyst more decisively into the domain of *acting-on*. In the case of the transfer assistants, however, on-line automation allowed them to "reabsorb" a data-entry function that had already been exteriorized and routinized. The data-entry clerks' function was reintegrated upwards; however, for the transfer assistants, like the benefits analysts, the new configuration of their task further distanced them from involvement in the managerial process.

AUTOMATING THE OFFICE

The Computer-Mediation of Clerical Work

The work of office clerks has always been more abstract than, say, that of a pulp mill operator or machinist. Clerks typically spend much of their time recording and processing papers full of written symbols that represent objects and events at some remove from their immediate environment. Despite this, the transition to computer mediation was experienced as a significant break with what they called the "manual" work of the traditional office. Though their feelings were not as intense as those of the pulp mill operators, the clerks at both Consolidated Underwriters Insurance and Universal Technology frequently felt off-balance and discomforted by the new computer-mediated task relationship. They viewed the old environment as "manual" work—pulling and filing ledgers, writing, and handling papers. Each of these activities was physically engaging in an immediate, concrete way. "The other way was much more physical," one woman said. "Now your fingers do the walking—your fingers and your brain."

While most of the clerks in each office appreciated the ease with which a transaction now could be completed, many were also frustrated by the loss of the concreteness that had provided for them a sense of certainty and control. They wondered where the material on the screens "came from" and where it "went." Because the machine's operations were invisible, intangible, and largely inscrutable, learning to trust the computer system was initially an emotionally exhausting process. One transfer assistant tried to explain these uncertainties:

> It has been hard for many of us to accept that the machine is really going to do this for you. It's almost like you don't want to believe that the system is really doing that because it was never like that before. And we even ask ourselves, "O.K., is it really debiting the account out? How can I really be sure that these things are happening?"

In the first months after the conversion to an on-line system, many experienced the inclination to reach for the old aids, which could be touched and which provided a greater feeling of certainty. Managers tended to discourage this dependency on the concrete, however. They wanted the clerks weaned away from the old objects as quickly as possible. One benefits analyst described an experience shortly after the technological conversion:

> It was hard not to fall back to looking at the ledgers. One day, when we were still getting used to the new system, I got a call and I started to turn to get the ledger, and my supervisor saw me and she slapped my hand. She told me not to touch the ledger but to do the claim in the system. She said we cannot depend on the ledgers or check the ledgers.

Why was it felt to be important and natural to check the ledgers? Many of the clerks experienced a loss of certainty similar to that of the pulp mill operators when they were deprived of concrete referents. In the office the referent function operated at a higher level of abstraction than in the mills. For these clerks, written words on pieces of paper had become a concrete and credible medium—for several reasons. First, paper is a three-dimensional object that carries sensory weight—it can be touched; carried; folded; in short, dominated. Secondly, writing is a physical activity. The pen gives voice to the hand. Each written word is connected to the writer both through the intellectual relationship of authorship and through the immediate physical relationship of fingers and pen. In the act of writing there is a part of the self that is invested in and so identified with the thing written. It comes to be experienced as an extension of the self rather than an "otherness." This identification occurs so subtly, that it is rarely noticed until it has been taken away. Electronic text confronts the clerk with a stark sense of otherness. Text is impersonal; letters and numbers seem to appear without having been derived from an embodied process of authorship. They stand autonomously over and against the clerk who engages with them. A benefits analyst described the sensation:

> You can't justify anything now; you can't be sure of it or prove it because you have nothing down in writing. Without writing, you can't remember things, you can't keep track of things, there's no reasoning without writing. What we have now—you don't know where it comes from. It just comes at you.

The "hands-on" paper environment also made it possible to leave a trail of "trigger" stimuli, which provided the clerk with more information about the work than was required by the formal system of documentation. For example, benefits analysts would note on their ledgers various irregular contractual arrangements, customers' special problems, or unique agreements that they had worked out with a client. The customers' handwriting was sometimes the trigger that evoked memories of prior conversations and the particular issues associated with that account. The benefits analysts would make special notations on ledgers of the VIPs who were to be paid most promptly. The ledger thus provided not only a concrete referent in the transaction process but also a personal record of their own initiatives and judgments in dealing with an account. The computer system seemed, by comparison, to be impervious to their special knowledge. It had become impossible to put their personal stamp on their relationship with the customer.

Under these conditions, the sense of a concrete reality became vested in one source—the telephone. This remote and faceless medium came to represent a source of confirmation and certainty that to some degree compensated for the impersonality and abstractness of the computer system, simply because it afforded an opportunity to hear a real voice. A benefits analyst said:

> Now we have numbers without names—no ledgers, no writing, no history, no paper. The only reality we have left is when we get to talk to a customer.

The feeling of being out of control was both epitomized and confounded by the ENTER key. In an on-line system, pressing the ENTER key causes the transaction to be accomplished in the organization's central computer. Once taken, this action cannot easily be reversed. In both offices, clerks noted that it could take days or weeks for an error to be corrected, even though it was known seconds after the ENTER key was pressed. The immediacy and significance of the ENTER key often engendered anxiety. A benefits analyst explained:

> Now, once you hit that ENTER button, there is no way to check it, no way to stop it. It's gone and that's scary. Sometimes you hit the buttons, and then it stares you in the face for ten seconds and you suddenly say, "Oh no, what did I do?" but it's too late.

At the same time, the knowledge that one was actually accomplishing the transaction—not just completing paperwork—entailed a sense of control, responsibility, and seriousness. A transfer assistant put it this way:

> We have so much responsibility now because we not only approve the transfer but it takes place by the time it leaves our desks. Once you hit that button, it's gone; and you feel a lot of pressure to make sure you did it right.

The loss of concrete stimuli to trigger memory and the responsibility associated with the on-line system combined to increase the intensity of concentration and the continuity of attention that individuals must bring to their tasks. As routine as the transaction process might become, clerks in both offices widely agreed that the work requires a continual, conscious engagement. Most agreed that it has become easier to maintain this level of concentration, but few thought that it was possible for the execution of the work to become as routine as the content of the work. This is how a transfer assistant put it:

> We really did not have a need for such intensive concentration before. There are times when you are looking at the screen but you are not seeing what is there. That is a disaster. Even when you get comfortable with the system, you still have to concentrate; it's just that you are not concentrating on concentrating. You learn how to do it, but the need doesn't go away.

The need for concentration is not necessarily linked to the complexity of work content. In both offices, clerks perceived that the knowledge demands of their tasks had been diminished (there were also some significant differences in the degree to which each job had been simplified—an issue to be visited later in the discussion), but attentional requirements and responsibility had increased.[3]

The Diminished Importance of Substantive Knowledge

The managers with executive responsibility for each of these offices had clearly defined intentions. In each case, cost reduction and increased productivity were preeminent goals, which required systems that would simplify transaction processing while substantially increasing the volume of work that could be completed by one clerk. In the case of Consolidated Underwriter Insurance's dental claims operation, this meant reducing the knowledge demands of the task in order to increase the speed with which claims could be processed. The product manager for dental claims described the purpose of the new system:

> We were always a production environment, but now, with the computer system, it's more so. A lot of the quality issues are now built into the machine. It requires less thought, judgment, and manual interventions. It's designed to let you pump claims out the door.

The project manager with overall responsibility for seeing that the new system not only fulfilled its purpose but also could be used as a model for back office automation throughout the corporation expanded on this theme:

> We rely on the notion that the system does things better than humans do. It is amazing how people were able to remember rules and exceptions. When you give them the system, they stop remembering and rely on the system. We debriefed all the special deals and arrangements that applied to each account and programmed it right into the system to maintain existing situations. We cracked down on idiosyncratic options. All options are now built right into the system.

Consultants advising the company on the design of the new system advocated that all tasks involving elements of interpersonal coordination, such as collecting mail or answering the telephone, be eliminated from the benefits analyst's job in order to maximize productivity. With the benefits analysts focusing only on claims processing, the consultants predicted a 70 percent productivity increase; however, they forecast only a 60 percent increase if the job was allowed to remain "enriched." The project manager dissented from the consultants' recommendations and chose to retain these vestiges of diversity, believing that "there's a limit to how boring you can make a job if you want even reasonably capable people." Despite his decision, by the end of 1983, two years after the system's implementation, productivity had increased by 105 percent and continued to climb. Even this manager felt somewhat appalled at the nature of the job he had helped to create:

> It's reached a point where the benefits analysts can't move their fingers any faster. There is nowhere to go anymore if you don't want to sit in front of a terminal. The quantity of pressure may be the only difference. Labor will sooner or later get smart and see that unions are their only answer.

In the case of the Stock and Bond Transfer operation in Universal Technology, the goals were somewhat more complex. There was a driving commitment to reduce labor costs and increase productivity. The regulatory environment also had a role to play: the Securities and Exchange Commission now required that such transfers be accomplished within seventy-two hours. This made it important to have a system in which transfers could be tracked easily and supervisors could identify processing bottlenecks. The company was also committed to improving its service to shareholders by providing more information, more functions, and improved response times. Finally, Universal Technology's managers were explicitly concerned with what they called "creating meaningful jobs." A senior manager described their intentions this way:

> We insisted that the new system take into consideration human needs. We wanted the computer to do as much record keeping as possible, but we don't want to make the job worse. We wanted to make it easier for them to judge whether they had entered data correctly, where the case stands in the process, and to take responsibility for a real-time update. We wanted to avoid overspecialization—denuding the job or whatever you want to call it.

Line managers with responsibility for the transfer operation believed that although the new system had simplified the work, the complexity of the task itself imposed a limit on just how much could be routinized and, therefore, programmed. Transfer assistants remained responsible for reviewing the legal documentation associated with a transaction and making sure that they had all the material required for executing the transfer. The system broke down each step of the transfer process and required the transfer assistant to move logically through the series of machine interactions. The program would not allow an operation to continue until all logic requirements had been satisfied. Still, the system could not account for those materials handled by the transfer assistant but not entered into the data base, thus leaving an additional measure of responsibility and judgment in the hands of the transfer assistants. There remained enough exceptional and unusual transfer procedures that, unlike the dental claims operations, all contingencies could not be accounted for in the system.

Employees in each office had strong feelings about the simplification of their jobs. They recognized that the computer system now contained much of the knowledge upon which they had once prided themselves. In the dental claims operation, benefits analysts were accustomed to memorizing a great deal of information associated with each account. Some could recite complicated arrangements, triggered only by seeing a customer's signature or hearing the customer's voice. In the new environment, the combination of several factors—the increased volume of transactions required to be processed each hour, the loss of written records, the impersonalization that resulted from feeding the machine numbers (for example, social security numbers) rather than words (for example, the customer's name), and the fact that all arrangements were now stored in the system—caused a shift in the benefits analysts' relationship to the substance of their task.

> The computer system is supposed to know all the limitations, which is great because I no longer know them. I used to, but now I don't know half the things I used to. I feel that I have lost it—the computer knows more. I am pushing buttons. I'm not on top of things as I used to be.

In each office the clerks believed that they were overqualified for the tasks as they were now organized. The knowledge they had acquired was now less important than typing skills and the sheer stamina needed to meet daily production quotas. As their bodily presence became more important than their knowledge, the women began to see these jobs as circumscribed by the animal body, barely requiring distinctly human forms of intelligence. Compare the lament of a benefits analyst:

> You don't have to think that much because the system is doing the thinking for you. You don't have to be concerned with what is on that claim. People here have begun to feel like monkeys.

with that of a transfer assistant:

> You don't have to remember things, because the system does. You could get a monkey to do this job. You just follow the keys.

If in the cases of the benefits analysts and transfer assistants the primary effect of computerization was a reduction in opportunities for the exercise of already acquired know-how, then these cases would indeed conform to the typical pattern of craft deskilling as a result of automation. This component of deskilling does indeed appear to be amply accounted for both in the observations of the clerks and in the explicit intentions of their managers. However, computerization has transfigured these jobs in yet another way. These parallel effects illustrate the discontinuity between clerical jobs that have retained some vestige of the managerial process, as reflected in the ongoing necessity for interpersonal coordination and communication, and clerical jobs that have been pushed more fully into the domain of *acting-on*, which demands little in the way of skill but makes considerable demands upon stamina. In this process, the white-collar body is detached from its skillfulness as a medium of communication and social action, and reemerges in its availability for effort and sustained attention.

The Clerk as a Laboring Body

The knowledge traditionally associated with clerical work is not limited to the substantive knowledge of the methods by which a task should be executed. Such substantive understanding has been embedded in a much wider, richer, more detailed, and largely unspecified interpersonal reality. It is through "informal" contact with peers and supervisors that appropriate courses of action generally are determined. Office work is chatty, but that chattiness is more than a social perquisite of the job. It is the ether that transmits collaborative impulses, as people help each other form judgments and make choices about the work at hand. As we saw in the previous chapter, office functions have always had a "soft" character. They have been sufficiently unspecified so that clerks, in collaboration with their supervisors, must take on a certain amount of coordinative and communicative responsibility if the work is to be accomplished in a way that can be held accountable to generally recognized criteria of orderliness and rationality. In other words, despite recurrent efforts to rationalize clerical work, clerks must retain at least a slender hold on the managerial process if things are to run smoothly. Their knowledge is reflected in the collaborative problem-solving abilities related to *acting-with* as much as in technical mastery of their administrative functions.[4]

The office has been the action context in which clerical know-how is embedded. Its social and material aspects provide the clerk with the concrete cues necessary for the development of competence. The social dimension is crucial because the interactions with others who are facing or have faced similar contingencies inform judgments about what to do. The material dimension provides a context for unspecified informal collaboration, based upon the proximity of individuals and their accessibility in face-to-face communication.

Despite the degree to which the jobs of the benefits analysts and the transfer assistants had been rationalized prior to computerization, each had retained much of the character of traditional office work; each had been infused with the practical necessities of interpersonal coordination and communication in order to accomplish "smooth" operations. While my own data do not include first-hand documentation of these earlier activities, the accounts of the clerks and their supervisors in each of these offices attest to the transformational effect of the computer system (and of the choices about how it would be managed) on those practical *acting-with* functions once associated with clerical work.

A key aspect of system design in both cases was to locate the resources for accomplishing a transaction within the computer system to the maximum extent possible. This meant that a clerk could accomplish most of what was needed without ever rising from her chair. Either the necessary information was available through the terminal or the system's procedural organization had reduced problem-solving requirements by eliminating the need to make choices about technical aspects of the transaction process. The abstraction of the computer medium imposed new attentional demands, and the production pressures were derived from managers' beliefs about how to fully exploit this new form of technological support. These additional elements, when combined with the notion of the machine as a unitary resource, had a withering effect on the sociality of the office environment. The elimination of social exchange not only diminished the quality of the work environment but also demonstrated the elimination of precisely those aspects of the clerk's work that had derived from the managerial function.

In some cases, the reduction of social exchange resulted from the way managers chose to interpret the new work arrangements and from the behavioral norms they sought to enforce. In both offices, managers wanted the clerks to realize that social engagement was no longer a legitimate dimension of work behavior.

> The computer system is giving you a message. It's saying, "You don't have to be on top of it anymore." The thing is, we make a lot of mistakes, and the less you encourage people to know things, the less anybody is ever likely to notice all these errors.

At Universal Technology, most transfer assistants agreed that the immediate impact of the system on their jobs was one of reducing the need for task-related knowledge and judgment. Because the system had been designed to break down the transaction into a series of simple steps, and because there were built-in safeguards to prevent errors, many transfer assistants saw that there was little possibility of mistakes. As long as one followed the prompts at each step, the process required minimal thought.

> The way I do my work now is by pushing buttons. We have all had formal training to tell us what buttons to push to get the information that we want.
>
> I have no decision making on that computer. It's been programmed to do this, and this, and this, and we are programmed to do the same thing. I don't want to be programmed. It does things automatically, and if you feel it's wrong, you really have no choice but to let it go that way on this formatted screen.

Some transfer assistants wondered how the company could afford to be so entirely dependent on its computer systems. Like the workers in Cedar Bluff, they found that when the computer went down, there was nothing to do but sit and stare.

> If the system doesn't work, nothing gets done. We sit there all day and smoke—there is nothing you can do. Everything is at a standstill.

One powerful means that managers used to communicate and enforce new patterns of conduct was the material organization of the office—

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the placement of people and furniture. A benefits analyst told the following story:

> We used to be able to see each other and talk. Sure, sometimes we just talked about what we were going to make for dinner, but we always worked while we talked: Most of the time, we talked about something related to a claim. Then with the new system, they put in two filing cabinets between us, because we weren't supposed to see each other anymore. But there was a small space between the two cabinets, so she could still turn around and look at me, and we would talk across to one another. Well, one day a manager walked by, and I was asked who left this space there. I said that was how they left it when they put the cabinets in. The manager had them move the cabinets together because they don't want us talking.

The Stock and Bond Transfer operation reflected the same tensions. The line manager with direct responsibility for the office discussed the use of furniture to shape new behaviors:

> There's not a whole lot of need for people to interact with one another anymore. The system allows you to be really very private between you and the system. Now with the furniture we've chosen, that's another reinforcement of the message, "Here you are, doing your own job." It's designed for increased productivity because it puts everyone in their own little cubicle. Some people can work well that way, but others cannot. Some supervisors are noticing that people are asking questions of one another even though the system tells you just about everything you need to know. I have wondered about this—do people really have questions or do they just want to talk? Maybe they just want to hear someone's voice talking to them.

Opportunities for social exchange were also diminished as a result of the organization of the work itself. Since the computer system contained most of the resources a clerk needed to complete the transactions, even as it simplified the required procedures, it tended to obviate any need for collaboration or inquiry. One result was to isolate individuals at their workstations, with the exception of breaks for coffee or lunch. Again, the benefits analysts comment:

> I think we're all more separate now. Before, there was more that I could help someone out with. There's not really that much I can do now. You just don't seem to get to know people the way you did when you were paying manually, because you don't interact.

> The office has become much more impersonal now, because we don't talk to each other. The girl who pays the Consolidated Underwriters' claims sits right in front of me. There was a question on my claim form. She didn't turn around and ask me. She sent me a letter. She didn't realize it was me. I said, "Cindy, do you know that you sent me a letter?" She said, "Did I really?"

In the Stock and Bond Transfer office, the manager with direct responsibility for the transfer operation reflected on the relationship between the design of the system and the changing behavioral requirements of the work:

> The system controls the transfer assistants in some ways because it ties them to the desk. It forces them to do the input and to really be tied to the machine. That forces control in terms of physically having to just be there.

A transfer assistant remarked:

> When we were just working at our regular desks, you could see an individual face to face, and you had a lot more tendency to say, "Hey, I don't remember such and such. What's the answer?" rather than looking in your reference material. Now everyone's partitioned off from each other. People are less likely to get up out of their desks and come over and ask you a question. I think it has a lot to do with the simple fact that we just don't see each other's faces anymore.

A supervisor noted that because the system eliminated the need for social exchange, instances of interaction had become easy indicators that a clerk was encountering problems in doing her job.

> Now if I repeatedly see somebody at another person's desk, I'm going to go over and see what the problem is. It becomes obvious when they don't know how to do something.

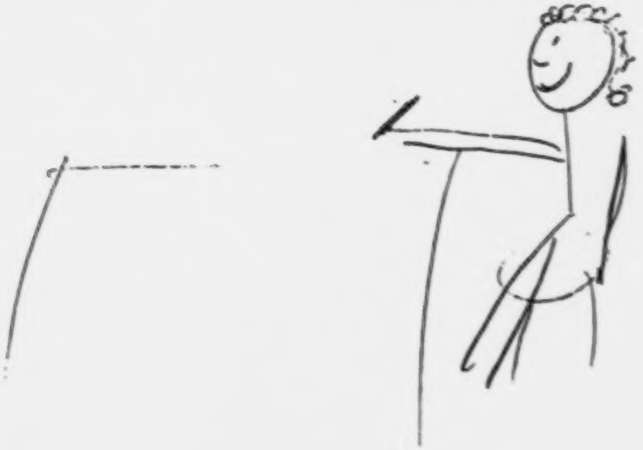
As a result of the computerization process, the jobs of the benefits analyst and the transfer assistant were removed from the evolutionary path that had characterized traditional clerical work. A discontinuity had been created, and these new jobs could no longer be counted as descendants of the managerial process. Being "tied to the machine," as so many had described their jobs, was understood to be an inferior status, severed from the managerial function. As one transfer assistant put it, "Working with the CRT [video screen] is doing the dirty work."

It is small wonder, then, that so many of these clerks' complaints about the work became complaints about bodily suffering. The clerks in both offices repeatedly spoke of eye strain, nervous exhaustion, physical strain, irritability, enervation, sedentariness, back pain, short tempers and intolerance, and a host of other concerns—from visual distortion to fears about microwaves. Automation meant that jobs which had once allowed them to use their bodily presence in the service of interpersonal exchange and collaboration now required their bodily presence in the service of routine interaction with a machine. Jobs that had once required their voices now insisted they be mute. Jobs that had been able to utilize at least some small measure of their personhood now emphasized their least individually differentiated and most starkly animal capacities. They had been disinherited from the management process and driven into the confines of their individual body space. As a result, the employees in each office became increasingly engulfed in the immediate sensations of physical discomfort.[5]

During my discussions with these office workers, I sometimes asked them to draw pictures that represented their "felt sense" of their job experience before and after the conversion to the new computer system. Frequently these pictures functioned as a catalyst, helping them to articulate feelings that had been implicit and hard to define. I invited them to use pictures, diagrams, symbols, or any means that helped them express their sense of their situation. No particular themes were singled out for illustration; rather, I stressed the importance of expressing whatever they felt but found difficult to convey in words.

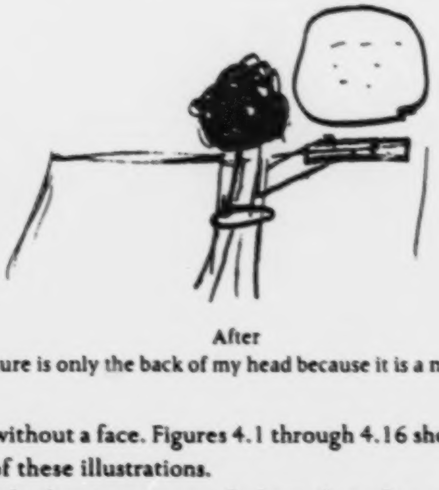
Perhaps the most striking feature of the clerks' pictures is their similarity. Though the pictures were drawn in private sessions, the images used by individuals both within each office and across the two offices were quite consistent. Moreover, the pictures from the two offices, taken as one set, can be grouped into distinct categories. One group of pictures (the largest) illustrated a single theme: the various forms of bodily alteration resulting from the new conditions of work, including hair loss; impaired eyesight; contortion of facial muscles; radical decrease in bodily dimensions; rigidification of the torso, arms, and faces; inability to speak or hear; immobility; headaches; and enforced isolation. The clerks portrayed themselves as chained to desks, surrounded by bottles of aspirin, dressed in prison stripes, outfitted with blinders, closely observed by their supervisors, surrounded by walls, enclosed without sunlight or food, bleary-eyed with fatigue, solitary, frowning,

Figure 4.1 Transfer assistant



Before

Figure 4.2 Transfer assistant



After

"The after picture is only the back of my head because it is a nonperson."

and blank—without a face. Figures 4.1 through 4.16 show a representative sample of these illustrations.

These simple drawings convey feelings that often elude verbal expression. The condition of being "tied to the machine" represents a new kind of confinement, not just the spatial confinement of having to sit in one place for long stretches, but an interior confinement. These clerks, driven into the confines of the laboring body, have seen their

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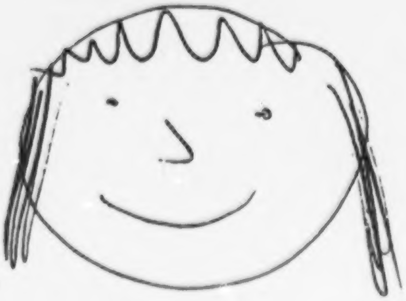
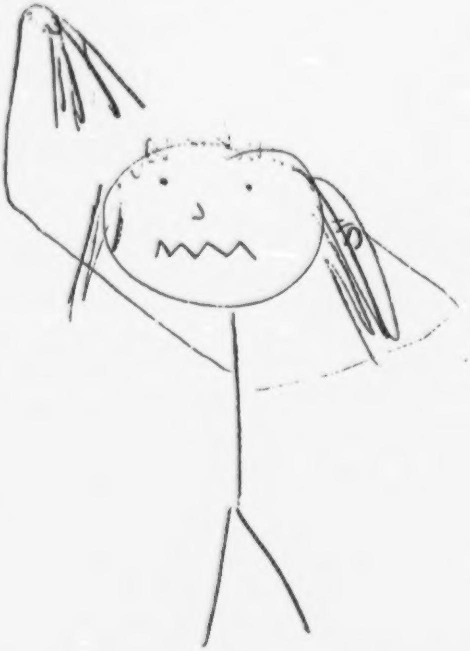
Figure 4.3 Transfer assistant



Before

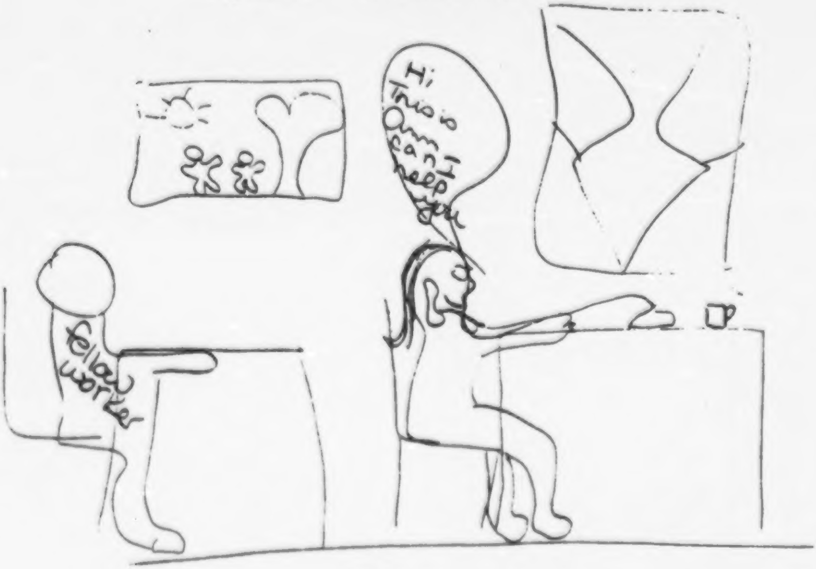
Figure 4.4 Transfer assistant



After

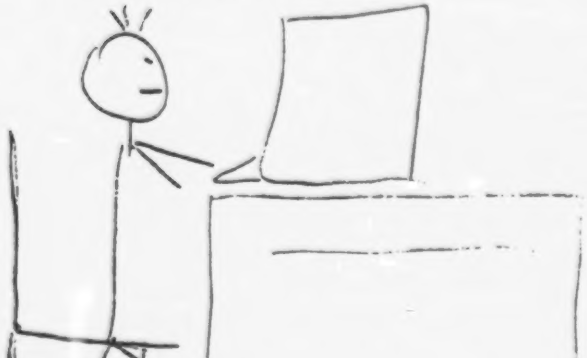
"There's a lot of tension now, and that makes people get mean. We had more control before and less confusion. You could get things done. Every once and a while my head starts to throb. I can't take it."

Figure 4.5 Benefits analyst


Hi This is Ann can I help you
fellow worker

Before

Figure 4.6 Benefits analyst



After

"I used to have someone behind me in case I needed to tell them about this irate phone call. But now there isn't anybody there. Now she is stiff. She is all by herself. You feel stiff. You're just out there."

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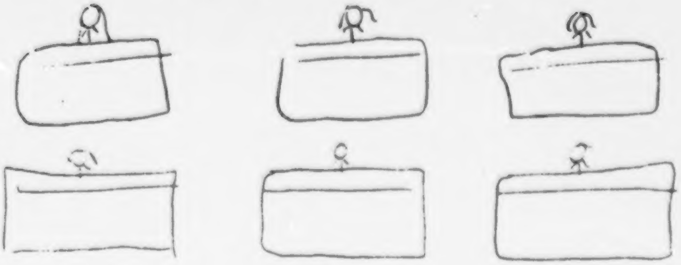
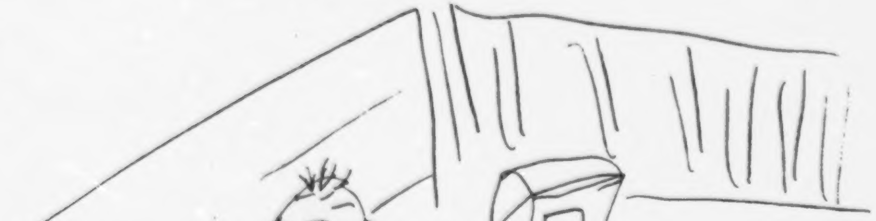
Figure 4.7 Benefits analyst



Before

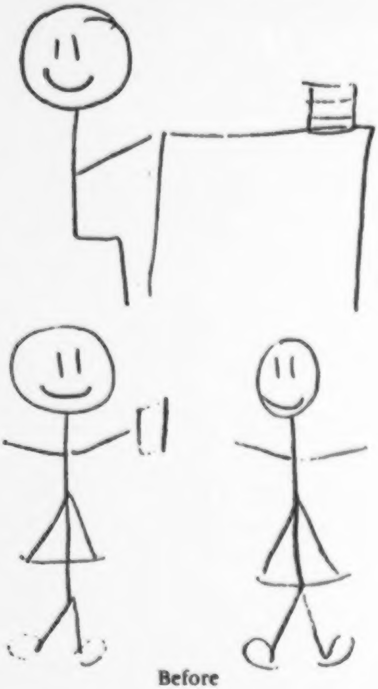
Figure 4.8 Benefits analyst



After

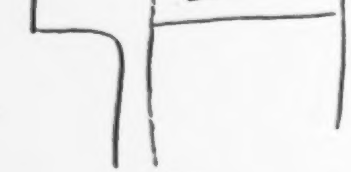
"No talking, no looking, no walking. I have a cork in my mouth, blinders for my eyes, chains on my arms. With the radiation I have lost my hair. The only way you can make your production goals is give up your freedom."

Figure 4.9 Transfer assistant



Before

Figure 4.10 Transfer assistant



After

"Before I was able to get up and hand things to people without having someone say, what are you doing? Now, I feel like I am with my head down, doing my work."

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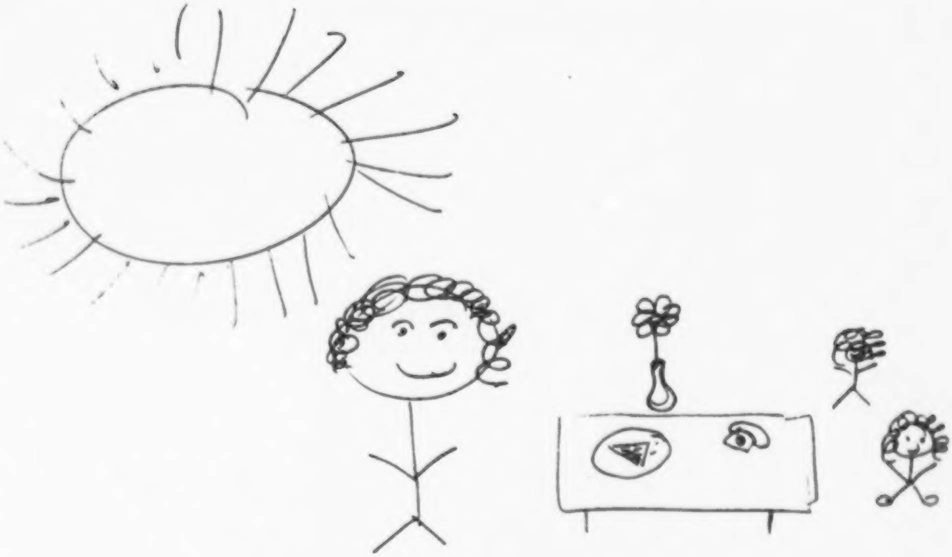
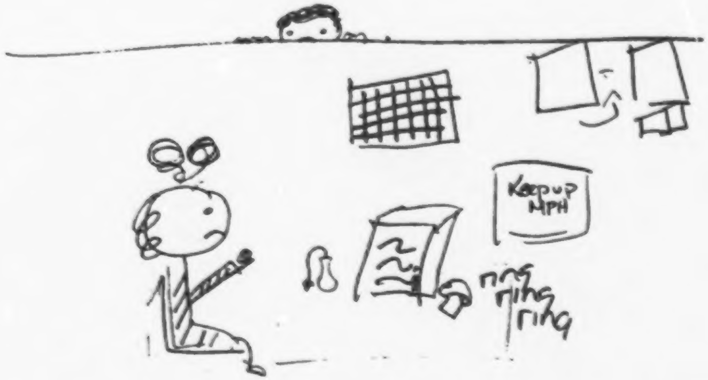
Figure 4.11 Benefits analyst



Before

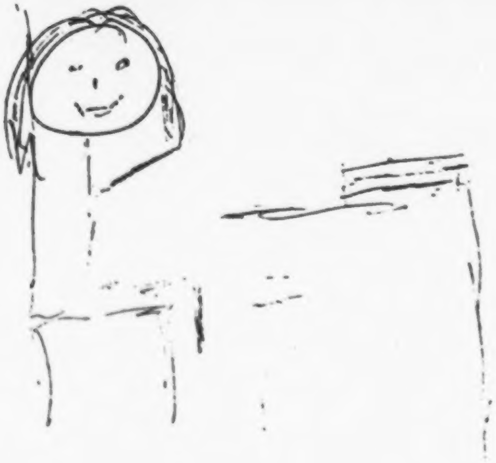
Figure 4.12 Benefits analyst


Keep up MPH
ring
ring
ring

After

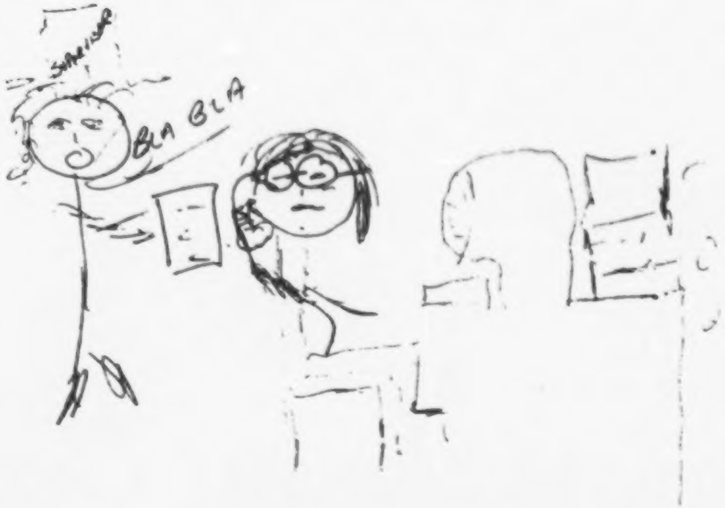
"My supervisor is frowning because we shouldn't be talking. I have on the stripes of a convict. It's all true. It feels like a prison in here."

Figure 4.13 Benefits analyst



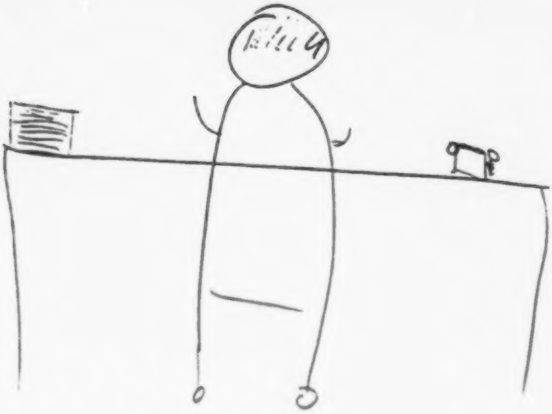
Before

Figure 4.14 Benefits analyst


SUPERVISOR
BLA BLA

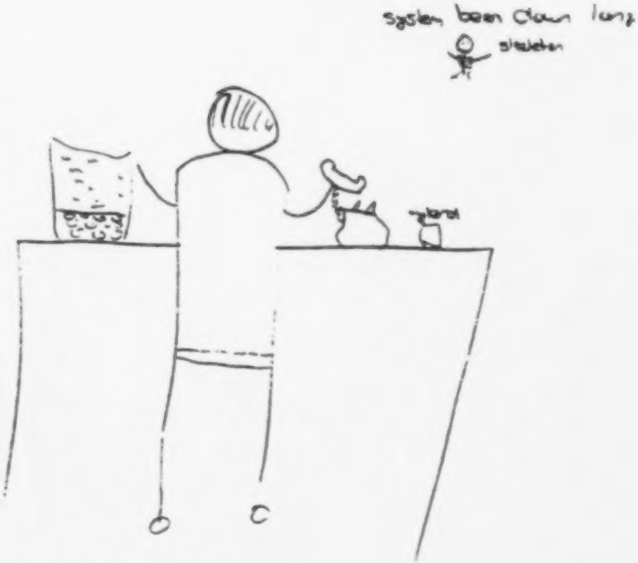
After

Figure 4.15 Transfer assistant



Before

Figure 4.16 Transfer assistant


system been down long
skeleton
tylenol

After

robs them of opportunities for using interpersonal and substantive skills. The principal challenge of their current jobs is an effort of endurance. It is a sullen effort, subtly corrosive, felt in diffuse interior discomforts, rarely dramatic, but persistent and inescapable.

The Clerk in Exile

Another measure of the alteration in these jobs was the perception that a new gulf had opened up between the clerks and their supervisors. Their relationship had been one of the most important arenas for mutual collaboration in problem solving and information sharing. As coordinative and communicative opportunities were eliminated from the office worker's domain, the clerks felt a new distance from their supervisors, a feeling that was acknowledged by the supervisors as well. Previously, the unspecific nature of their office tasks had required that clerks and supervisors collaborate on a myriad of practical but underdetermined discursive activities. As clerical work was reduced to the terms of machine interaction, the need to collaborate with supervisors became as infrequent as the need to collaborate with peers. The supervisors found themselves in much the same position as did bookkeepers earlier in this century. The clerks' enforced self-sufficiency did not displace the supervisory function; rather, it appeared to draw the supervisors away from a direct involvement with the execution of clerical transactions toward an increased emphasis on coordination.

Benefits analysts described these changes in the clerk-supervisor relationship:

> Before, the analyst worked directly with their supervisor. Now we are looking into these electronic boxes. The supervisors are totally separate, even farther away than we are from each other. The supervisors used to sit down and do a difficult claim with you, and now they don't. We're closed in now, and we don't have any communications anymore.

These changes were also apparent to the supervisors:

> Our relationship with the analysts is more distant now. We are able to supervise more people because they are so much more independent. The system now calculates the benefits for the analysts, so they do not seek us out as much. So you do not have as much of a personal relationship with them as you might have had in the past. We tend

> to get more involved in writing letters and corresponding in problem cases, or helping out the assistant manager on projects. We have more of a focus on looking at the big picture of how the work is flowing, how best to organize it and try to keep things moving.

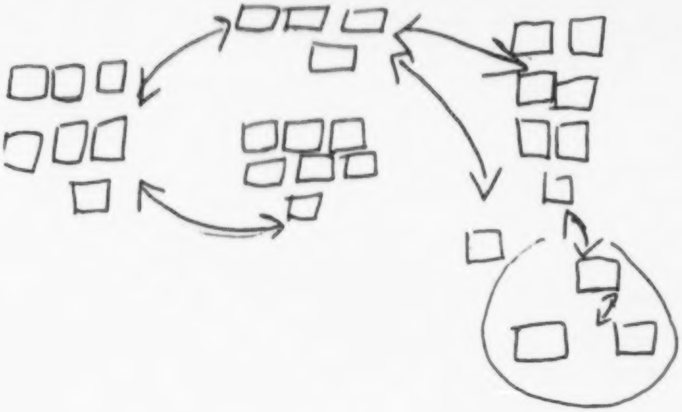
A similar redefinition of the supervisor-clerk relationship was evident in the experiences of transfer assistants and supervisors in the Stock and Bond Transfer office. One transfer assistant summarized this change:

> Most of the communications between transfer assistants and the supervisors has been lost. All the data that the supervisors need they can get right from the machine. Before, they would just walk around and ask each one of us. We still have communication with them about career development, feedback, appraisals, if you're a bad girl, if you're a good girl. It's like your supervisor doesn't need you as much anymore.

A second group of pictures drawn by the clerks and their supervisors illustrate both the isolation of the individual office worker and this new sense of distance between the clerical function and those who supervise it. Figures 4.17 through 4.24 include four sets of these before and after drawings.

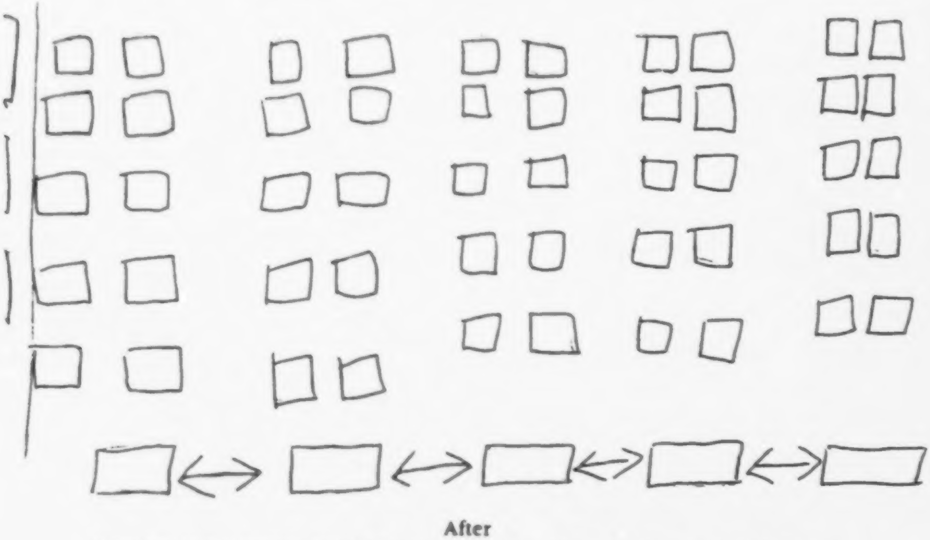
In the offices of Consolidated Underwriters Insurance and Universal Technology, the transformation of clerical work has extended Leffingwell's dearly held principles concerning the application of scientific management to the elusive tasks associated with administrative support. Leffingwell idealized the image of a job that was pure labor—continual production uninterrupted by the coordinative and communicative demands of administration. The new forms of clerical work that he and other practitioners of scientific management created shared an emphasis on the bodily effort of the office worker. For the first time, the "desk" job began to closely parallel the logic of unskilled factory work. In the case of the benefits analysts and transfer assistants, the technology had been used to automate: it was treated as a highly sophisticated form of office machinery. Automation had pushed the clerks into activities that concern *acting-on*, removing the social and material dimensions of office life that once provided the context for the action-centered skills associated with the ordinary but vital activities of social problem solving. It entailed a more complete form of exile from the

Figure 4.17 Dental claims supervisor



Before

Figure 4.18 Dental claims supervisor



After

"Under the old system, people interacted more with each other. I think that now the supervisors interact more with each other and not as much with their units. We are not as dependent on them or them on us as we were under the other system. The supervisors are involved in the office as a whole rather than their own unit."

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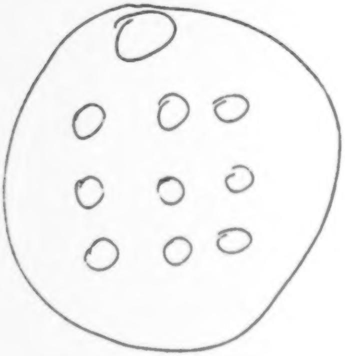
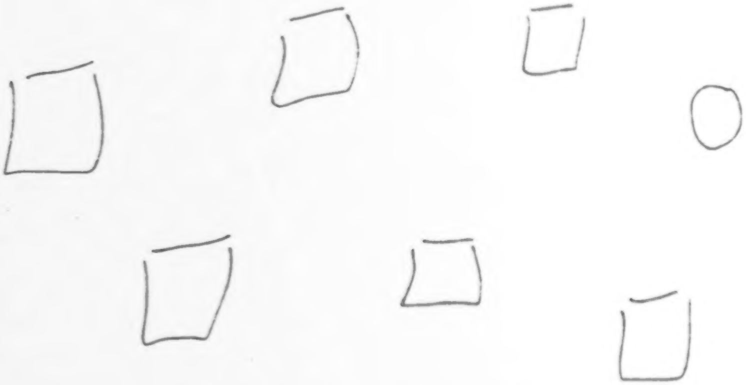
Figure 4.19 Dental claims supervisor



Before

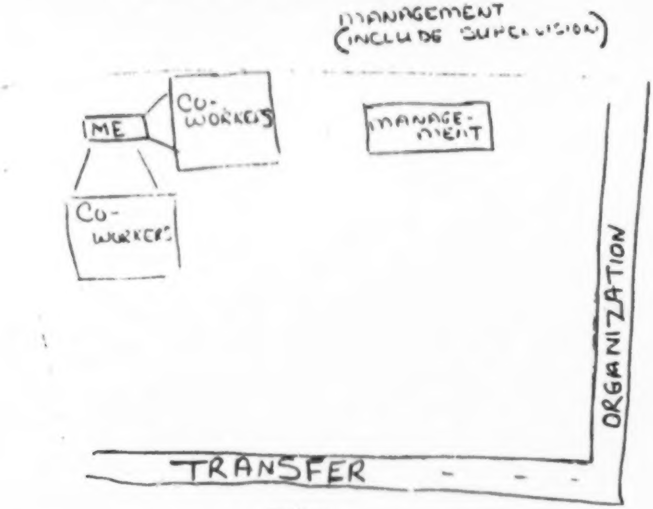
Figure 4.20 Dental claims supervisor



After

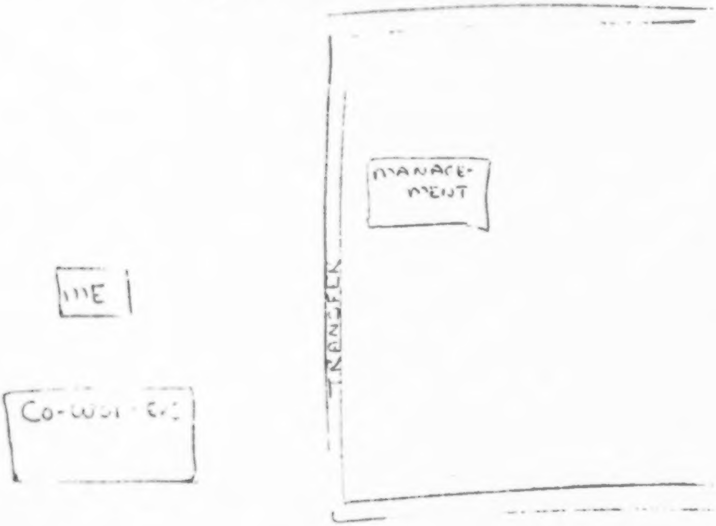
"Before, we were all pulling files. You knew everyone. And now it is, like, everybody has their own desk and they do not really need me. They kind of do their job. They need me for questions they cannot handle, but for the most part, a girl can come in all day and not ask me anything and go home at night. I do not feel they are as close to me as we were before, and they are not as close with each other. Not that the office should be like a party, but before we were more of a family."

Figure 4.21 Transfer assistant


MANAGEMENT
(INCLUDE SUPERVISION)
ME
CO-WORKERS
CO-WORKERS
MANAGE-MENT
ORGANIZATION
TRANSFER

Before

Figure 4.22 Transfer assistant


MANAGE-MENT
ME
CO-WORKERS
TRANSFER

After

"Before, I felt part of my co-workers. I felt we had some kind of camaraderie. I still felt management was separate, but we were all part of Transfer. We were an organization with everyone inside it. We seemed to be working for the same thing. Now I think management has become much more distant. They are so hung up over figures and commitments and this whole change that computerization has brought. They have just taken Transfer and put it around them and forgot about us. I feel as though I am much more alone now."

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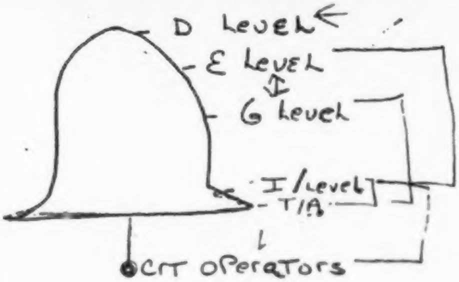
Figure 4.23 Transfer assistant

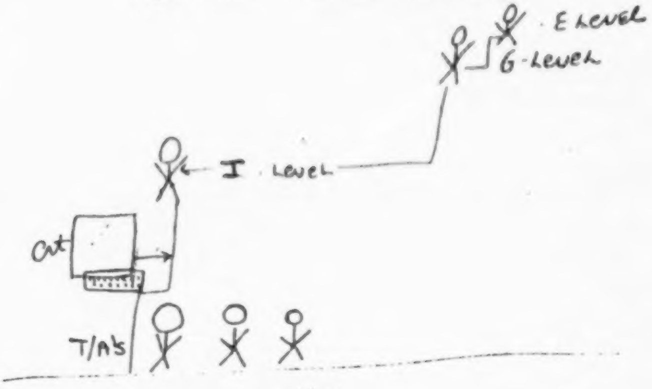


Before

Key

D-level	Upper managers	I-level	Supervisors
E-level	Middle managers	T/A	Transfer assistant
G level	Assistant managers	CRT	Data-entry clerk

Figure 4.24 Transfer assistant



After

"Before, your nonmanagement CRT operator hung at the bottom of the pyramid. No communication; they are down there by themselves. But you have a lot of communication between your transfer assistants and your supervisors. The other levels—I guess they communicated but we never saw them, except your E and G levels, they communicated a lot. We could not do anything without involving the supervisors. They would ask for input from us, but they never dealt directly with the poor CRT operators. Now we have their little nowhere job. Now the supervisors have a closer relationship to the machine than they do to us. There are things that they used to have to depend on us to find out. Now they can go right in the machine and find out anything they want. They don't have to communicate as often. The communication has been lost. They look at reports and spend all their time with numbers."

managerial process, creating a new felt distance between the clerk and the managerial organization. It also allowed first-line supervision to become more thoroughly integrated with the management function, which, paradoxically, brings into focus the otherwise-neglected informating power of the very same technology.

Informated Elements in the Automated Office

Describing the effect of office technology as an occasion for exile still falls short of fully describing the emerging nature of office work. There remains a missing element, and it is one that provides a clue to an alternative conception of information technology and office work.

In both the offices of Consolidated Underwriters Insurance and Universal Technology, the new information systems provided a rationalized, public, independently authored electronic text that was treated as a complete account of the information necessary for smooth operations. This text relied upon an objective (thus, in theory, universally accessible) language thick with codes and numbers, as compared with the personal language each clerk had invented to both trigger and convey a wealth of implicit knowledge. The inherent abstractness of this text, constituted by the invisible procedures of its authorship; the impersonality of its language; the intangibility of its content, and the autonomous electronic "other" character of its enduring presence, placed unique mental demands upon the clerks. They experienced a need for vigilance and sustained concentration. Knowing that their input would be inscribed immediately onto a permanent record and would, without further intervention, initiate a series of interdependent organizational operations (for example, checks mailed, accounts credited) imposed an additional measure of tension and purpose upon this attentional effort. Clerks needed skills in procedural reasoning in order to successfully navigate the programmed logic that controlled their interaction with the text.

While the informating power of the technology resulted in a more comprehensive textualization of office work, it did not lead to an increase in the intellectual content of clerical tasks. Instead, these tasks embodied the uneasy requirement of sustained concentration and procedural reasoning without offering substantive content to naturally anchor the clerk's attention. This is because, in both cases, managers and designers chose to emphasize the automating rather than the informating capacity of the new technology. The technology's informating power was not seen as an occasion for creating new sources of value in customer service. To paraphrase the dental claims product manager, the idea was to pump more work out the door. For these managers, volume had overtaken service as the key to profits.

There are, however, some indications in the data from the Stock and Bond Transfer operation that the informating consequences of the technology were not lost on employees. Though their managers had not yet achieved a conception of the work that really would have exploited these consequences, the observations of supervisors and transfer assistants at least are suggestive of an alternative approach.

It was the supervisors in Stock and Bond Transfer who benefited most from the informating power of the new technology. The textualization of the operations that they supervised provided them with a wider, more accurate, timely, and accessible record of work. They were able to use this text to augment and enhance their supervisory function. As one of them explained:

> The best part about having this new system is knowing what is in the unit and being able to feel like I have control over the work. That is one of my responsibilities, but I never felt like I had that control before. We were constantly chewed out by management—"You should have done this or that." If I had known what was going on, if I had had a clear picture of it, I might have been able to do the right thing. Now that I can see the total functioning of the office, I feel more ownership towards all of the units, not just my own. I do more coordination of the work flow with my peers. I finally feel like I am really doing my job. I am not just a record keeper, but I can really use my brain.

In this situation, supervisors are informated on the basis of, and at the expense of, their subordinates who are automated. While this contributed to the perceived distance between the clerks and the supervisors, the transfer assistants did experience at least some positive effects of the technology's informating power. For example, many felt they were able to provide better service to the shareholders with whom they frequently had telephone contact:

> Having everything on-line is fantastic. Now as soon as a transfer is completed, it's there! You can really look up what you need. If someone calls, you know exactly what's going on. Sometimes you are looking for a part of a case that someone else has. You used to have to go looking around for it, and maybe you wouldn't find it. Now

> you can see where it is without ever getting up from your seat. It's all right there at my fingertips.

The benefits analysts at Consolidated Underwriters Insurance had little to say about the informating effects of the technology. However, discussions with the senior managers revealed a vision of their technological future (at least as it applied to operations like claims service) that differed dramatically from the current narrow emphasis on automation. This vision gave primary importance to the informating power of computer systems, based upon a more efficient automated infrastructure. They planned to use a combination of interorganizational information systems (for example, systems that could provide data directly from the health care providers, eliminating routine in-house data-entry functions such as dental claims), optical character recognition devices, and high-speed communications networks, in addition to the current emphasis upon on-line transaction processing, in order to create a comprehensive, highly automated, data base that would provide a continually updated portrait of the organization's business.[6] This kind of integrated data base increases the visibility of a firm's productive and administrative activities. It provides a powerful means with which to gain new insight into and control over business functions. The integration of text and data processing can create informated environments in which organization members can "see" and understand the business in new ways.

Earlier, I suggested that the automated dental claims and transfer systems had begun to textualize the work of the office. An integrated organizational data base is a more ambitious effort, as it attempts to textualize the work of an entire organization. It constitutes a new technological infrastructure, a new medium in which the business of the organization is observed and enacted. According to a recent study of technology in the insurance industry, many leading companies, like Consolidated Underwriters Insurance, are exploring this approach as an initial step in the next major phase of technological development. The study concludes that "the next stage of office automation is integrated information processing." The strategic goal is to develop a technological infrastructure whose informating capacity can be used to support both "clerical and decision-making functions."[7]

Indeed, the managers at Consolidated Underwriters Insurance believed that this data-base environment would create a new kind of office job. Employees would be needed to work with the data base,

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manage exceptional cases, and use the information for improvements in customer service. The managers believed such jobs would require skills related to information management as well as technical knowledge of insurance products. In other words, these new positions would exploit the informating capacity of the new infrastructure and would demand intellective skills. In this way, the automated office, which had intensified the industrialization of the clerical worker and completed her or his exile from the managerial process, was seen as a transitional solution to the relentless pressures of volume and cost. The new vision was one of fewer clerks but better jobs—jobs that at every level would be enriched by an informating technology.

INFORMATING THE OFFICE: WORK AS ELECTRONIC TEXT

Global Bank Brazil provided the opportunity to explore the development of just such an integrated data-base environment. During the period of my research visits, that organization was involved in the planning and initial implementation of what they called "a new phase of technological development" in banking. Although the full range of the project would take several more years to complete, the early data suggest how an informated environment might reconfigure patterns of conduct, sensibility, and skill within the various levels of a white-collar organization. In particular, they indicate how the traditional skills related to *acting-with* may be eroded and the new qualities of knowledge that are likely to substitute for, or complement, that action-centered know-how.

The point here is not to set up a direct comparison between the two clerical operations we have discussed and Global Bank Brazil. These organizations were in distinct phases of technological evolution, and the systems under consideration were designed to address different problems. What the Global Bank Brazil case does provide, however, is a better understanding of the choices that may eventually face the managers at Consolidated Underwriters Insurance and Universal Technology. As they accomplish a more efficient and complete textualization of office work, what kinds of opportunities for creating value will they perceive? What kinds of jobs will they create? Will the technology finally become the occasion for a reintegration of clerical and managerial occupations? In short, what might it mean to move from an automated to an informated office?

In Global Bank Brazil, the impetus toward data-base technology development came from the need to improve internal operating efficiencies as well as from a commitment to building a data infrastructure that banking professionals could exploit in order to create new value-added, information-based products and services. For Global Bank Brazil, the data-base environment concept represented a technological strategy in direct support of its competitive strategy. Because this case represents an opportunity to investigate the linkages between competitive strategy in a service enterprise, technological development, and organizational transformation, it is worthwhile to trace briefly the business context that provided the drive for Global Bank Brazil's approach to the technology.

During the late 1970s and early 1980s, international banking experienced wrenching changes. Revenues from traditional sources, such as lending, decreased, and banks became more dependent on fees generated from new products and services. Deregulation meant that banks also faced increased competition from nontraditional banking sources, particularly other financial services companies. Finally, the Latin American debt crisis had caused the major institutions to reexamine their lending and marketing strategies.[8] As a result, many banks were racing to develop their capacity to utilize computer technology, both for productivity and for the development of information-related products and services.[9]

Global Bank had become a leader in high-tech banking. Global Bank International (the division that serviced corporate clients around the world) led the way with technological applications (telecommunications networks, automated delivery vehicles, on-line cash management, data-base services, electronic funds transfer, and letter of credit and foreign exchange services) that between 1979 and 1984 represented investments in technology of $1.5 billion, almost half of what the entire bank had allocated for expenditures on technology during that period.

The international division's leadership saw the technological infrastructure as vital to achieving its strategic objectives, which included an emphasis on product expansion, differentiation, and cost allocation, coupled with continued market penetration in key countries and the customization of services for local clients. The development of value-added products and services was considered the most important factor in accelerating the pace of revenue growth.

Global Bank Brazil was one of the largest and most profitable U.S.-based banks in Brazil. In 1984 the revenues from the Brazilian operations represented almost 20 percent of the parent corporation's total profits. Global Bank Brazil was growing rapidly, but the debt crisis had given particular urgency to the new business strategy. Dollar loans, which had been a principal source of revenue, had been eliminated. New fee-based revenues, many of which would be generated from information-intensive products and services, were crucial for Global Bank Brazil's continued growth and financial success.

During 1984 many discussions at the bank focused on the difficulty of defining banking products and the challenge of creating what they called a "product-oriented culture." It was clear that the bank's expertise with information technology would play a crucial role, both in the content of new products and in the processes used to develop them. While there was no single definition of new products, there was a consensus about three important requirements: quick response to a rapidly changing financial environment, flexibility to customize products, and high information content as a means of adding value. Diverse ideas were being generated:

> We could buy information and build integration of information from several sources and give it to the client. We could find out how they dream. Give them information about real estate to buy a house . . . and then tell them we'll provide the loan for the house, too . . . and insurance . . . then we've got him hooked.
>
> With the right data-base technology it becomes cost-effective for us to provide our clients with a continual and accurate picture of their cash position. We can manage their accounts payable and accounts receivable through our system. We can advise them when they need a loan or when they have an excess of funds they should invest.
>
> With a data-base environment, we can see that Company A needs money and Company B has money to loan. We can broker that loan for them, analyze the credit risk, and charge a fee for undertaking that risk. The data base allows a broad integration of data from many companies so you can really find opportunities. This kind of data used to be in one broker's head. Now it can be in a data base with a vast memory.

Each of these products depended on a sophisticated technological infrastructure that could integrate data from the bank's internal functions, as well as from its clients and other external data bases, while providing opportunities for flexible access to information, data manipulation, and analysis. The existing technological infrastructure did not fulfill these criteria. It had been built to "automate the factory," with an exclusive focus on internal operations, high-volume transactions processing, and cost reduction. The systems were designed in separate modules representing different functions, and they did not "talk" to one another. Changes in the regulatory environment necessitated different calculations and required that each module be updated separately. Depending on when the system was accessed, reports could show different numbers, and the awkward updating procedures created a constant stream of errors. Some managers estimated that only 20 percent of the standardized reports available from the systems were ever utilized, mainly because they provided what managers referred to as "an autopsy of the corpse"; that is, data about events that had already occurred rather than data about processes under way. Moreover, it was impossible to access these various systems according to one's own immediate and specific analytical needs.

The leaders of both the operations and the financial control divisions in Global Bank Brazil, which had primary responsibility for technology and financial data, saw the need for a new technological infrastructure. They believed that it should provide a data base in which numbers were accurate and consistent, and that it should integrate data from the various functional areas for easy use in the creation of new products and services. In other words, the bank had used its massive investment in technology almost exclusively as a means to automate its transaction base. Now the time had come to build on that base and finally exploit the technology's unique informating capacity. They made a commitment to a new project, one that would develop and implement a database environment in Global Bank Brazil. Though such an undertaking was ambitious and costly, they, together with other senior managers, believed that Global Bank Brazil's experience would provide a model for other Global Bank operations around the world.[10]

For the Global Bank Brazil managers and technologists who became involved in the conception, planning, and implementation of the database environment, it represented "a new direction for the bank . . . the infrastructure for the new business plan . . . a big piece of the overall strategy." These managers explained the data-base concept as "a library . . . a place where I can do research," "experiment with any idea," and "implement ideas immediately." One project member explained:

> We'll be able to see what's happening. Not only will we have numbers, but we'll be able to see the dynamics for yesterday, today, and tomorrow. Using the projection capability, you can see immediately the impact on earnings or the portfolio. We'll be able to see the business through the terminal.

As the business became available for more rigorous analysis, project members believed that bankers (that is, middle- and senior-level professionals with client responsibilities) would be able to "manage the business instead of just reacting to individual client situations." They saw the data-base environment as the infrastructure needed to create new value-added information products and anticipated new product discoveries based on the ability to explore a variety of financial configurations. Another banker explained:

> Eighty percent of the bank's products can be produced with 150 procedures. The other 20 percent of the products require at least that many procedures. It's like a production line. We want a data base that will give us the pieces to assemble. If you use the same procedure in a different order, you would get a different product; or you could eliminate one procedure, and you'd get a different product. When data is independent from the function, you create an infinite number of products. Data and procedures—that's the conceptual thinking that's required.

Many people also saw the data-base environment as a way to consolidate and formalize information currently existing in a variety of informal media. The data base could transpose data from people's heads or personal files into a unified, visible, accessible medium.

> Today I have to work hard to get information from folders, letters, scraps of paper, conversations. It's very confusing. Now I'll get information easily.

The project team worked over a two-year period on the planning and initial stages of implementing the data-base environment. As their activities intensified, bankers and clerks alike began to consider the likely implications of the new technology for their tasks, especially concerning the nature of the skills they would need. They anticipated two ways in which current patterns of skill were likely to be challenged and potentially transformed. First, many managers identified the current importance of action-centered skills to the professional activities of the banker as well as the clerical work force. They feared that the new environment would encroach upon, displace, or transform the traditional importance of such implicit know-how.

A crucial arena in which action-centered skills had contributed to a banker's success was that of managing the relationship with the customer and assessing credit risk (account officers were referred to as "relationship managers"). They described the "art" of banking as "the ability to develop a gut feel of the client" based on business discussions as well as social activities like luncheons, golf games, and cocktail parties. These activities were not considered frivolous but were seen as vitally important sources of data. The relationship between banker and customer was an example of action-centered skill related to *acting-with*; it demanded the bodily presence (gut) and personal sensibility of the banker in a face-to-face action context:

> Our credit decisions have been more related to feeling than to technical skill. For big loans, the officer knows the client and the client's environment. He spends time with that person. They dine together, play golf together. That is why we specialize by industry and company size. This is why the officer comes to know things that are not written. Credit is given by the feeling in one's stomach. Technological development and the more challenging demands of our marketplace will change this. The objective component of the decision will be increased as we have data visible to all. You can make the terms of lending so secure that the gut-feel credit judgment becomes secondary.

Many others agreed that the growing information presence and the availability of flexible analytical software was turning this "art" of banking into a science. They claimed that decisions "will be on more solid ground, not just based on feelings."

> Now managers are seat-of-the-pants people wearing goggles and white scarves. But we're moving too fast, too high, and too quick, and we can't fly by the seat of our pants now. The new technology provides a sophisticated means of navigating in the business environment. Holding your finger up to the wind won't be acceptable anymore.

> A banker used to be a salesman—a lot of interaction and personality involved. Now people who are good will manage and use information to be better . . . on a more objective and scientific basis. They'll be more analytical, and make more use of computing and statistical management tools.

Action-centered skill had another role to play. Despite the bank's huge investment in technology, the rapid growth of Global Bank Brazil had made it difficult to keep up with the demand for automation. There were many back office processes that continued to rely, either in part or entirely, on manual means. Many professionals and clerks were accustomed to dealing with paper and pencil, with the same hands-on, personally developed know-how that had characterized the dental claims clerks' interactions with their ledgers. One manager described the operations of the bank as full of "artisans who make information by hand."

The central liabilities operation was one of the first slated to go online with the new data base.[11] The current procedures in that area still depended upon a great deal of written documentation, ledger cards, and personal files. The senior operations manager in charge of the largest branch office in Brazil was concerned about the implications of the technological change for the kind of knowledge upon which his office and others like it had depended:

> Today, my people do notations in a ledger with pens. They write down rules in the ledger about how we will do a given type of transaction. Some ledgers have ten years of written history in them. The knowledge that people have is very personal. It is connected to their own thinking, their own writing. It's my writing, my data; I do it, I make it. I am concerned that we will lose contact with the data, which is after all the original data base. Man needs to feel, to touch the data. With the new technology, the contact with the data is impersonal.

The concerns about loss of contact with the actual dynamics of the business due to this impersonal quality of the new data environment was also voiced by professionals in relation to their own work:

> The old banker is a bloodhound—he sniffs out deviations. The auditor is a bloodhound, too. You learn to recognize when something is wrong. With the manual system, we had a smell for errors. You could pick up the ledger, scan it. The sense is formed by years of experi-

> ence. Now the bloodhounds are disappearing. You can't sniff the new technology.

There was a second way in which people expected the data-base environment to affect the nature and distribution of skill. The growing consensus was that a depth of intellective skill would be required at each level of the organization. Through the first half of the 1980s, technological development had automated processes in a way that eliminated, minimized, or simplified human intervention. To the extent that technology had penetrated the work of professionals and clerks, many believed that it had not only encroached on action-centered skills but also failed to replace those skills with new forms of knowledge that could become the basis for new competencies. The computer system had become a black box into which a great deal of intelligence about banking procedures had been loaded. People at all levels had become dependent on that box and were poorly acquainted with much of the financial logic that was fundamental to the banking business.

Some managers reflected on what had happened to the clerical and lower-management work force. In their view, this group once contained the "knowledge of the bank"—an understanding of how the transaction base operated. With the automation of the 1970s and 1980s, as we also saw in Consolidated Underwriters Insurance and Universal Technology, much of that knowledge had been stored in the machine.

> With our automated systems, the clerk's tool became a terminal. . . . You don't need to think, because the machine makes the calculations and performs the control. People don't understand the meaning of their jobs. It's a void. A clerk goes in and out of a task, but whoever made the system is the only one who knows what is in the box.
>
> As we have more and more processing in the black box, fewer people know what a bank is really like. Some guys now are walking encyclopedias of banking information, but they are a dying breed. Do we need people who really know all the processes? Is there a risk?

Others pointed out that these growing knowledge deficiencies and machine dependency were not restricted to the lower levels of the organization. Bankers had lost much of their technical knowledge of the business. The head of the technology division explained the history of automation in the bank this way:

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> The technologists have concentrated intelligence in the machine. The user pushes the button, and it's done for them. You don't have to know bookkeeping or understand the general ledger. In the old days, people had that intelligence. When you make loans manually, you have to understand the dynamics of the loans you are making. With automation, you just fill out the forms. People stop using their skills, and pretty soon they don't know the business very well.

Another banker explained:

> Now the banker loses knowledge when he uses reports produced by the system. They don't know how to do it manually anymore. The machine calculates, and people see reports with figures that they themselves could not produce. They are unfamiliar with the basic concepts of the business, the basic accounting principles.

These dynamics can be recast in the historical perspective developed in chapter 3. The work of the banker had entailed considerable technical and action-centered knowledge. The technical aspects were most subject to rationalization and so could be carved out and repositioned in lower-level management or even clerical routines. With the growth of automated systems, this knowledge increasingly came to be lodged in software, further reducing the skill requirements of those lower-echelon jobs, transforming them into machine-oriented procedures. As this process continues, the organization arrives at a point where most of its technical knowledge is embodied in software, and very little of it is developed or required in the course of ordinary professional or clerical activities.

The liveliest debate in the bank centered on whether the data-base environment would exacerbate this trend or reverse the downward spiral of banking skills. Some were beginning to realize that a data-base environment, without a knowledgeable work force to utilize it, would be of little value:

> If people aren't aware of the opportunities in the data-base environment to use the integrated information it can make available, then they will only be terminal operators. They will be filling in the blanks on the screen rather than thinking.

The senior technology planners agreed that the data-base environment required an entirely new logic of skill development:

> The data-base environment means a concentration on data, not on procedures. You have to choose which procedures you want to impose on which data. This means that using the technology becomes a very creative process. It will push people's intelligence. Everyone will be a systems analyst, using their business expertise. We will have to think before pushing buttons.

Many managers agreed that a serious training investment would be required if organizational members were to have the skills necessary to exploit the informating power of a data-base environment. But what might be the kinds of skills that would be necessary?

In a series of discussions with managers who were informed about the new technology, their reflections as to the nature of the new skill demands began to take shape. They anticipated a kind of knowledge that closely paralleled the intellective skill profile that we have already seen in the informated plant environment discussed in chapter 2. First, they widely agreed on the problem of meaning as a central challenge in the informated organization.

> There is a big difference between the person who knows and the person who just looks at the screen. You must know your business to use the data base. You find yourself asking, "What does it mean?" "What am I looking at?" There need to be many mechanisms available for answering that question.

Second, they believed that people would need to be more oriented toward abstract thinking. People were accustomed to thinking of products as material things. Now they would have to think of products as conceptual innovations. "We need to have some people with a new frame of mind," said one banker. "Bankers tend to have very square minds. They think concretely. We will need people who are conceptualizers, who are not afraid to think in abstractions and to learn through analysis." One manager, who had spent his early career in the navy, provided the following analogy as a way of illustrating the implications of the change:

> I spent years and years on the bridge of a ship looking for the horizon, and gave orders based on the information my eyes gave me. With computer technology, the commander of a ship is no longer on the bridge. He is in a room filled with computers. Now he looks at the screen with a lot of information and makes decisions. He must have new ways of making sense. He must feel the numbers, trends, and

> plots, and relate it to the outside, to what really happens. He must reconstruct the scenario from the information on the screen. I believe the same thing is happening in the bank—bankers will have the same problem.

Some bankers had already begun to recognize that data-based inferential reasoning would be a crucial aspect of these new skills. They believed that a more theoretical understanding of the business would provide the means by which people would "navigate" in the information-rich environment.

> The banker needs to know the structure of the data and associations, relationships, and links within the data. To navigate in the data base, you need a conceptual model of the business, the data, the logic. Users have to define their conceptual model of the bank . . . to make the model in their heads explicit. For the first time they will need to know the meaning of their work.

As in the mills, the ability to handle the comprehensive array of data would depend in part on "top-down" processing, which, in the absence of an immediate action context, is in turn dependent upon theoretical understanding.

Finally, managers repeatedly identified the need for procedural reasoning based upon a comprehensive grasp of the information system. People would have to know what data are available, how they are accessed and analyzed, and how they might relate to other sectors of data. Information would no longer be organized according to separate bank operations:

> The new technology makes you look at the whole. Tasks become more comprehensive as a result. You need to know where to look for what you need and how to get it. You need to see patterns in relation to the whole.

Some managers felt strongly that the clerical positions created during the past decades of mechanization would become obsolete. The jobs, like the ones at Consolidated Underwriters Insurance and Universal Technology, had become increasingly mechanized and specialized. The new technological infrastructure would integrate many disparate functions and eliminate the need for a great many of the simple procedures that still required repetitive clerk-machine interaction. Just as the insurance executives envisioned future changes in the clerical function that would make the job more comprehensive and intellectually demanding, these bank managers foresaw a new semiprofessional role that would replace the current clerical job. As in most organizations, clerical work had proliferated as a means of isolating and efficiently dispatching the most routine aspects of the organization's work. The new phase of technological development would begin to reverse this process. Routine tasks would be either subsumed by automatic processes or subcontracted out to a processing organization external to the bank.

Activities that had once been extracted from the professional domain and rationalized in lower-level jobs could now be reintegrated with those higher-level positions. For example, bankers could interact directly with the data base, perform analyses, and develop ideas. The remaining clerical positions would take on a quasi-professional status, requiring information management and business knowledge.

> The information will be available to everyone. We are "killing" the clerks as we know them now. The new clerk must be trained to make decisions, to deal with the information relevant to that function. It will mean a need for more educated people. You can't just type in information and not know what it means. At the same time we will need far fewer clerks. Data will be entered and accessed by the people who have it and use it. The vice-president will learn to use a keyboard, and eventually he will become a pianist.

The clerks in the central liabilities area also realized that management had some clear choices to make. In the past, they had received minimal training in operating computer technology. Like the other clerks we have heard from, they were taught to push buttons and little else. Would implementation of the data-base environment really represent a new approach? Would they be trained to handle information and perform their jobs in a new way? Would they be given the skills to make a more valuable contribution? The clerks expressed their concerns, but the answers to their questions were still unclear.

> We need a more global view so we can solve our problems when we have them. When you just push buttons and don't have a general idea of what it is . . . that's not much of a job. The most important thing is to know my job in the context of all the tasks of the bank. How else can I exercise any judgment?

> I wish senior management would think about how to give information to the people. Give more training and information about the bank and the technology and the business. They take a person and say, "Sit here and do this and do that." If I have no opportunity to learn, I have no value. Will things be any different now?

WILL THINGS BE ANY DIFFERENT NOW?

The history of the white-collar body has led to a series of questions regarding the application of information technology in the office. Would the technology be used, like the office machinery of earlier decades, to further disinherit the clerical position from its managerial legacy? Might it be the occasion for a reintegration of clerical work with the managerial function? How would either of these scenarios affect the managerial role? How might the increased textualization of work affect the knowledge that managers, as well as clerks, would require? Would the presence of technology increase the rationalized content of the middle-management job and encroach on those skills related to *acting-with*? Would the intellective component of the manager's function be enlarged?

The evidence presented in this chapter suggests the dynamic interplay between intrinsic and contingent aspects of information technology and illustrates some of the ways in which these questions might be answered. At Consolidated Underwriters Insurance and, in a more qualified way, at Universal Technology, we saw information technology applied in ways that resembled Leffingwell's goals for office machinery, with an almost exclusive emphasis on the technology's automating capacity. In these settings, the clerk was absorbed into the machine system, and the managerial process became anchored in the supervisory role. In the context of managerial choices that emphasize cost reduction, productivity, and increased volume, the clerical experience became one of laboring bodies engrossed in the demands for ongoing physical and attentional stamina, and removed from the forms of social exchange that once signified their integration with the managerial hierarchy.

However, these two cases also reveal a crucial distinction between computer systems and the office machines that preceded them. The further development of office machinery begets only new and more specialized office machinery. Typewriters, adding machines, filing systems—equipment may become more sophisticated, but its function does not change. In contrast, the further development of computer systems unleashes their informating potential. As time frames become more immediate, as more sectors of data can be integrated, as software helps limit inaccuracies, as data entry and access become more widely distributed, and as programmed logic becomes more comprehensible and flexible, the surrounding life-world of the organization comes to be more comprehensively reflected in a dynamic, fluid electronic text. New methods of automating this textualization process, such as building it into organizational members' natural activities (for example, account officers enter their own data), sharing it among several organizations through interorganizational systems, and relying on increasingly sophisticated automated data-entry devices based on optical character recognition and high-speed communications, mean that fewer people will be needed to accomplish routine transactions in conjunction with the machine system.

This new scenario calls into question both the forms of knowledge that people need and the way in which that knowledge should be distributed. New intellective skills are required, but the mere fact of this requirement does not imply that it will be fulfilled. As some members of Global Bank Brazil feared, institutions may be unable to respond to the technological presence other than as an occasion for decreasing their dependence on human talent, ignoring the opportunities to gain value from the technology in a qualitatively different way. However, one thing seems clear—the informating potential of the technology cannot be exploited without human skills in ways of thinking that are conceptual, inferential, procedural, and systemic.

When the clerk at Global Bank Brazil asks, "Will things be any different now?" one wants to answer, "Yes!" Rational analysis suggests that things indeed should be different now. However, rational analysis neglects some of the most trenchant features of organizational experience—realities that cut to the quick of managerial power as it is conceived and displayed in everyday life at work.

Before we can determine whether things will be different, what may drive them to be so, and what may impede change, chapter 5 will consolidate the evidence from the mills and the white-collar settings in order to better define the qualities of knowledge associated with an informated organization. With that in hand, we will move on to confront these dilemmas of power and see if, and how, that crucial question—Will things be any different now?—might be answered.

3

SOCIAL CHOICE IN MACHINE DESIGN

D.F. NOBLE

D.F. Noble 'Social choice in machine design', in A. Zimbalist (ed.), *Case Studies on the Labor Process*, Monthly Review Press, New York, 1979, pp. 18–50.

Introduction

Almost everyone would agree that the technology of production and the social relations of production are somehow related. The explanation of this relationship often takes the form of a more or less "hard" technological determinism: Technology is the independent variable which effects changes in social relations; it has its own immanent dynamic and unilinear path of development. Further, it is an irreducible first cause from which social effects automatically follow. These effects are commonly called its "social impact."

Social analysts have recently begun to acknowledge that the technology and the social changes it seems to bring about are in reality interdependent, and it has become fashionable to talk about the dialectic between the forces of production and social relations. Nevertheless, most studies of production continue to focus primarily on the ways in which technology affects social relations and there is precious little effort made to show precisely how technology reflects them. That is, although grantsmanship now demands that people refer to the mutual dependence of technology and society, and although socialists and other radicals now take it for granted that technological development is socially determined, there remains very little concrete, historical analysis that demonstrates the validity of the position. The present essay, a case history of the design, deployment, and actual use of automatically controlled machine tools, is meant to be a step in that direction.

Elsewhere I have tried to show that technology is not an autonomous force impinging upon human affairs from the "outside," but is the product of a social process, a historically specific activity carried on by some people, and not others, for particular purposes (Noble 1977). Technology thus does not develop in a unilinear fashion; there is always a range of possibilities or alternatives that are delimited over time—as some are selected and others denied—by the social choices of those with the power to choose, choices which reflect their intentions, ideology, social position, and relations with other people in society. In short, technology bears the social "imprint" of its authors. It follows that "social impacts" issue not so much from the technology of production as from the social choices that technology embodies. Technology, then, is not an irreducible first cause; its social effects follow from the social causes that brought it into being: behind the technology that affects social relations lie the very same social relations. Little wonder, then, that the technology usually tends to reinforce rather than subvert those relations.

Here I want to render this abstract argument concrete by examining a particular technology. Moreover, I want to go a step further and show that the relationship between cause and effect is never automatic—whether the cause is the technology or the social choices that lie behind it—but is always mediated by a complex process whose outcome depends, in the last analysis, upon the relative strengths of the parties involved. As a result, actual effects are often not consonant with the expectations implicit in the original designs. The technology of production is thus twice determined by the social relations of production: first, it is designed and deployed according to the ideology and social power of those who make such decisions; and second, its actual use in production is determined by the realities of the shop-floor struggles between classes.

This essay is divided into six parts. A description and brief history of the technology involved is followed by a two-part section on social choice in design that discusses both the horizontal relations of production (between firms) and the vertical relations of production (between capital and labor). The fourth part examines social choice in the deployment of technology and the fifth looks at shop-floor realities where this technology is being used in the United States today. In the last part some alternative realities, with different social relations, are described.

The Technology: Automatically Controlled Machine Tools

The focus here is numerically controlled machine tools, a particular production technology of relatively recent vintage.

According to many observers, the advent of this new technology has produced something of a revolution in manufacturing, a revolution which, among other things, is leading to increased concentration in the metalworking industry and to a reorganization of the production process in the direction of greater managerial control. These changes in the horizontal and vertical relations of production are seen to follow logically and inevitably from the introduction of the new technology. "We will see some companies die, but I think we will see other companies grow very rapidly," a sanguine president of Data Systems Corporation opined (Stephanz 1971). Less sanguine are the owners of the vast majority of the smaller metalworking firms which, in 1971, constituted 83 percent of the industry; they have been less able to adopt the new technology because of the very high initial expense of the hardware, and the overhead and difficulties associated with the software (ibid). In addition, within the larger, better endowed shops, where the technology has been introduced, another change in social relations has been taking place. Earl Lundgren, a sociologist who surveyed these shops in the late 1960s, observed a dramatic transfer of planning and control from the shop floor to the office (1969).

For the technological determinist, the story is pretty much told: numerical control leads to industrial concentration and greater managerial control over the production process. The social analyst, having identified the cause, has only to describe the inevitable effects. For the critical observer, however, the problem has merely been defined. This new technology was developed under the auspices of management within the large metalworking firms. Is it just a coincidence that the technology tends to strengthen the market position of these firms and enhance managerial authority in the shop? Why did this new technology take the form that it did, a form which seems to have rendered it accessible only to some firms, and why only this technology? Is there any other way to automate machine tools, a technology, for example, which would lend itself less to managerial control? To answer these questions, let us take a closer look at the technology.

A machine tool (for instance, a lathe or milling machine) is a machine used to cut away surplus material from a piece of metal in order to produce a part with the desired shape, size, and finish. Machine tools are really the guts of machine-based industry because they are the means whereby all machinery, including the machine tools themselves, are made. The machine tool has traditionally been operated by a machinist who transmits his skill and purpose to the machine by means of cranks, levers, and handles. Feedback is achieved through hands, ears, and eyes. Throughout the nineteenth century, technical advances in machining developed by innovative machinists built some intelligence into the machine tools themselves—automatic feeds, stops, throw-out dogs, mechanical cams—making them partially "self-acting." These mechanical devices relieved the machinist of certain manual tasks, but he retained control over the operation of the machine. Together with elaborate tooling—fixtures for holding the workpiece in the proper cutting position and jigs for guiding the path of the cutting tool—these design innovations made it possible for less skilled operators to use the machines to cut parts after they had been properly "set up" by more skilled men;* but the source of the intelligence was still the skilled machinist on the floor.

The 1930s and 1940s saw the development of tracer technology. Here patterns, or templates, were traced by a hydraulic or electronic sensing device which then conveyed the information to a cutting tool which reproduced the pattern in the workpiece. Tracer technology made possible elaborate contour cutting, but

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* The use of jigs and fixtures in metalworking dates back to the early nineteenth century and was the heart of interchangeable parts manufacture, as Merritt Roe Smith has shown (1976). Eventually, in the closing decades of the century, the "toolmaker" as such became a specialized trade, distinguished from the machinist. The new function was a product of modern management, which aimed to shift the locus of skill and control from the production floor, and the operators, to the toolroom. But however much the new tools allowed management to employ less skilled, and thus cheaper, machine operators, they were nevertheless very expensive to manufacture and store and they lent to manufacture a heavy burden of inflexibility, shortcomings which one Taylorite, Sterling Bunnell, warned about as early as 1914 (cited in David Montgomery, unpublished ms.). The cost-savings that resulted from the use of cheaper labor were thus partially offset by the expense of tooling. Numerical control, as we will see, was developed in part to eliminate the cost and inflexibility of jigs and fixtures and, equally important, to take skill, and the control of it, off the floor altogether. Here again, however, the expense of the solution was equal to or greater than the problem. It is interesting to note that in both cases expensive new technologies were introduced to make it possible to hire cheaper labor, and the tab for the conversion was picked up by the state—the Ordnance Department in the early nineteenth century, the departments of the army and navy in World War I, and the air force in the second half of the twentieth century.

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it was only a partial form of automation: for instance, different templates were needed for different surfaces on the same workpiece. With the war-spurred development of a whole host of new sensing and measuring devices, as well as precision servomotors which made possible the accurate control of mechanical motion, people began to think about the possibility of completely automating contour machining.

Automating a machine tool is different from automating, say, automotive manufacturing equipment, which is single-purpose, fixed automation, and cost-effective only if high demand makes possible a high product volume. Machine tools are general purpose, versatile machines, used primarily for small batch, low volume production of parts. The challenge of automating machine tools, then, was to render them self-acting while retaining their versatility. The solution was to develop a mechanism that translated electrical signals into machine motion and a medium (film, lines on paper, magnetic or punched paper tape, punched cards) on which the information could be stored and from which the signals could be reproduced.

The automating of machine tools, then, involves two separate processes. You need tape-reading and machine controls, a means of transmitting information from the medium to the machine to make the tables and cutting tool move as desired, and you need a means of getting the information on the medium, the tape, in the first place. The real challenge was the latter. Machine controls were just another step in a known direction, an extension of gunfire control technology developed during the war. The tape preparation was something new. The first viable solution was "record-playback," a system developed in 1946–1947 by General Electric, Gisholt, and a few smaller firms.* It involved having a machinist make a part while the motions of the machine under his command were recorded on magnetic tape. After the first piece was made, identical parts could be made automatically by playing back the tape and reproducing the machine motions. John Diebold, a management consultant and one of the first people to write about "flexible automation," heralded record-playback as "no small achievement . . . it means that automatic operation of machine tools is possible for the job shop—normally the last place in which anyone would expect even partial automation" (1952:88). But record-playback enjoyed only a brief existence, for reasons we shall explore. (It was nevertheless immortalized as the inspiration for Kurt Vonnegut's *Player Piano*. Vonnegut was a publicist at GE at the time and saw the record-playback lathe which he describes in the novel.)

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* The discussion of the record-playback technology is based upon extensive interviews and correspondence with the engineers who participated in the projects at General Electric (Schenectady) and Gisholt (Madison, Wisconsin), and the trade journal and technical literature.

The second solution to the medium-preparation problem was "numerical control" (N/C), a name coined by MIT engineers William Pease and James McDonough. Although some trace its history back to the Jacquard loom of 1804, N/C was in fact of more recent vintage; the brainchild of John Parsons, an air force subcontractor in Michigan who manufactured rotor blades for Sikorski and Bell helicopters. In 1949 Parsons successfully sold the air force on his ideas, and then contracted out most of the research work to the Servomechanisms Laboratory at MIT; three years later the first numerically controlled machine tool, a vertical milling machine, was demonstrated and widely publicized.

Record-playback was, in reality, a multiplier of skill, simply a means of obtaining repeatability. The intelligence of production still came from the machinist who made the tape by producing the first part. Numerical control, however, was based upon an entirely different philosophy of manufacturing. The specifications for a part—the information contained in an engineering blueprint—are first broken down into a mathematical representation of the part, then into a mathematical description of the desired path of the cutting tool along up to five axes, and finally into hundreds or thousands of discrete instructions, translated for economy into a numerical code, which is read and translated into electrical signals for the machine controls. The N/C tape, in short, is a means of formally circumventing the role of the machinist as the source of the intelligence of production. This new approach to machining was heralded by the National Commission on Technology, Automation, and Economic Progress as "probably the most significant development in manufacturing since the introduction of the moving assembly line" (Lynn et al. 1966:89).

Choice in Design: Horizontal Relations of Production

This short history of the automation of machine tools describes the evolution of new technology as if it were simply a technical, and thus logical, development. Hence it tells us very little about why the technology took the form that it did, why N/C was developed while record-playback was not, or why N/C as it was designed proved difficult for the metalworking industry as a whole to absorb. Answers to questions such as these require a closer look at the social context in which the N/C technology was developed. In this section we will look at the ways in which the design of the N/C technology reflected the horizontal relations of production, those between firms. In the following section, we will explore why N/C was chosen over record-playback by looking at the vertical relations of production, those between labor and management.

To begin with, we must examine the nature of the machine-tool industry itself. This tiny industry which produces capital goods for the nation's manufacturers is a boom or bust industry that is very sensitive to fluctuations in the business cycle, experiencing an exaggerated impact of good times—when everybody buys new equipment—and bad times—when nobody buys. Moreover, there is an emphasis on the production of "special" machines, essentially custom-made for users. These two factors explain much of the cost of machine tools: manufacturers devote their attention to the requirements of the larger users so that they can cash in on the demand for high-performance specialized machinery, which is very expensive due to high labor costs and the relatively inefficient low-volume production methods (see Rosenberg 1963; Wagoner 1968; Brown and Rosenberg 1961; Melman 1959). The development of N/C exaggerated these tendencies. John Parsons conceived of the new technology while trying to figure out a way of cutting the difficult contours of helicopter rotor blade templates to close tolerances; since he was using a computer to calculate the points for drilling holes (which were then filed together to make the contour) he began to think of having the computer control the actual positioning of the drill itself. He extended this idea to three-axis milling when he examined the specification for a wing panel for a new combat fighter. The new high-performance, high-speed aircraft demanded a great deal of difficult and expensive machining to produce airfoils (wing surfaces, jet engine blades), integrally stiffened wing sections for greater tensile strength and less weight, and variable thickness skins. Parsons took his idea, christened "Cardomatic" after the IBM cards he used, to Wright Patterson Air Force Base and convinced people at the Air Material Command that the air force should underwrite the development of this potent new technology. When Parsons got the contract, he subcontracted with MIT's Servomechanism Laboratory, which had experience in gunfire control systems.* Between the signing of the initial contract in 1949 and 1959, when the air force ceased its formal support for the development of software, the military spent at least $62 million on the research, development, and transfer of N/C. Up until 1953, the air force and MIT mounted a large campaign to interest machine-tool builders and the aircraft industry in the new technology, but only one company, Giddings and Lewis, was sufficiently interested to put their own money into it. Then, in 1955, N/C promoters succeeded in having the specifications in the Air Material Command budget allocation for the stockpiling of machine tools changed from tracer-controlled machines to N/C machines. At that time, the only fully N/C machine in existence was in the Servomechanism Lab. The air force undertook to pay for the purchase, installation, and maintenance of over 100 N/C machines in factories of prime subcontractors; the contractors, aircraft manufacturers, and their suppliers would also be paid to learn to use the new technology. In short, the air force created a market for N/C. Not surprisingly, machine-tool builders got into action, and research and development expenditure in the industry multiplied eightfold between 1951 and 1957.

The point is that what made N/C possible—massive air force support—also helped determine the shape the technology would take. While criteria for the design of machinery normally includes cost to the user, here this was not a major consideration; machine-tool builders were simply competing to meet performance and "competence" specifications for government-funded users in the aircraft industry. They had little concern with cost effectiveness and absolutely no incentive to produce less expensive machinery for the commercial market.

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* This brief history of the origins of N/C is based upon interviews with Parsons and MIT personnel, as well as the use of Parsons' personal files and the project records of the Servomechanism Laboratory.

But the development of the machinery itself is only part of the story; there was also the separate evolution of the software. Here, too, air force requirements dictated the shape of the technology. At the outset, no one fully appreciated the difficulty of getting the intelligence of production on tape, least of all the MIT engineers on the N/C project, few of whom had had any machining experience before becoming involved in the project. Although they were primarily control engineers and mathematicians, they had sufficient hubris to believe that they could readily synthesize the skill of a machinist. It did not take them long to discover their error. Once it was clear that tape preparation was the stumbling block to N/C's economic viability, programming became the major focus of the project. The first programs were prepared manually, a tedious, time-consuming operation performed by graduate students, but thereafter efforts were made to enlist the aid of Whirlwind, MIT's first digital computer. The earliest programs were essentially subroutines for particular geometric surfaces which were compiled by an executive program. In 1956, after MIT had received another air force contract for software development, a young engineer and mathematician named Douglas Ross came up with a new approach to programming. Rather than treating each separate problem with a separate subroutine, the new system, called APT (Automatically Programmed Tools), was essentially a skeleton program—a "systematized solution," as it was called—for moving a cutting tool through space; this skeleton was to be "fleshed out" for every particular application. The APT system was flexible and fundamental; equally important, it met air force specifications that the language must have a capacity for up to five-axis control. The air force loved APT because of its flexibility; it seemed to allow for rapid mobilization, for rapid design change, and for interchangeability between machines within a plant, between users and vendors, and between contractors and subcontractors throughout the country (presumably of "strategic importance" in case of enemy attack). With these ends in mind, the air force pushed for standardization of the APT system and the Air Material Command cooperated with the Aircraft Industries Association Committee on Numerical Control to make APT the industry standard, the machine tool and control manufacturers followed suit, developing "postprocessors" to adapt each particular system for use with APT.

Before long the APT computer language had become the industry standard, despite initial resistance within aircraft company plants. Many of these companies had developed their own languages to program their N/C equipment, and these in-house languages, while less flexible than APT, were nevertheless proven, relatively simple to use, and suited to the needs of the company. APT was something else entirely. For all its advantages—indeed, because of them—the APT system had decided disadvantages. The more fundamental a system is, the more cumbersome it is, and the more complex it is, the more skilled a programmer must be, and the bigger a computer must be to handle the larger amount of information. In addition, the greater the amount of information, the greater the chance for error. But initial resistance was overcome by higher level management, who had come to believe it necessary to learn how to use the new system "for business reasons" (cost-plus contracts with the air force). The exclusive use of APT was enforced. Thus began what Douglas Ross himself has described as "the tremendous turmoil of practicalities of the APT system development"; the system remained "erratic and unreliable," and a major headache for the aircraft industry for a long time.

The standardization of APT, at the behest of the air force, had two other interrelated consequences. First, it inhibited for a decade the development of alternative, simpler languages, such as the strictly numerical language NUFORM (created by A. S. Thomas, Inc.), which might have rendered contour programming more accessible to smaller shops. Second, it forced those who ventured into N/C into a dependence on those who controlled the development of APT,* on large computers and mathematically sophisticated programmers. The aircraft companies, for all their headaches, could afford to grapple with APT because of the air force subsidy, but commercial users were not so lucky. Companies that wanted military contracts were compelled to adopt the APT system, and those who could not afford the system, with its training requirements, its computer demands, and its headaches, were thus deprived of government jobs. The point here is that the software system which became the de facto standard in industry had been designed with a user, the air force, in mind. As Ross explained, "the universal factor throughout the design process is the economics involved. The advantage to be derived from a given aspect of the language must be balanced against the difficulties in incorporating that aspect into a complete and working system" (Ross 1978:13). APT served the air force and the aircraft industry well, but at the expense of less endowed competitors.

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* The air force funded development of APT was centered initially at MIT. In 1961 the effort was shifted to the Illinois Institute of Technology Research Institute (IITRI) where it has been carried on under the direction of a consortium composed of the air force, the Aircraft Industries Association (AIA), and major manufacturers of machine tools and electronic controls. Membership in the consortium has always been expensive, beyond the financial means of the vast majority of firms in the metalworking industry. APT system use, therefore, has tended to be restricted to those who enjoyed privileged access to information about the system's development. Moreover, the APT system has been treated as proprietary information within user plants; programmers have had to sign out

Choice in Design: Vertical Relations of Production

Thus far we have talked only about the form of N/C, its hardware and software, and how these reflected the horizontal relations of production. But what about the precursor to N/C, record-playback? Here was a technology that was apparently perfectly suited to the small shop: tapes could be prepared by recording the motions of a machine tool, guided by a machinist or a tracer template, without programmers, mathematics, languages, or computers.* Yet this technology was abandoned in favor of N/C by the aircraft industry and by the control man-

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for manuals and have been forbidden from taking them home or talking about their contents with people outside the company.

* Technically, record-playback was as reliable as N/C, if not more so—since all the programming was done at the machine, errors could be eliminated during the programming process, before production began. Moreover, it could be used to reproduce parts to within a tolerance of a thousandth of an inch, just like N/C. (It is a common mistake to assume that if an N/C control system generates discrete pulses corresponding to increments of half a thousandth, the machine can produce parts to within the same tolerances. In reality, the limits of accuracy are set by the machine itself—not to mention the weather—rather than by the electrical signals.)

ufacturers. Small firms never saw it. The Gisholt system, designed by Hans Trechsel to be fully accessible to machinists on the floor, was shelved once that company was bought by Giddings and Lewis, one of the major N/C manufacturers. The GE record-playback system was never really marketed since demonstrations of the system for potential customers in the machine-tool and aircraft companies elicited little enthusiasm. Giddings and Lewis did in fact purchase a record-playback control for a large profile "skin mill" at Lockheed but switched over to a modified N/C System before regular production got underway. GE's magnetic tape control system, the most popular system in the 1950s and 1960s, was initially described in sales literature as having a "record-playback option," but mention of this feature soon disappeared from the manuals, even though the system retained the record-playback capacity.*

Why was there so little interest in this technology? The answer to this question is complicated. First, air force performance specifications for four- and five-axis machining of complex parts, often out of difficult materials, were simply beyond the capacity of either record-playback or manual methods. In terms of expected cost reductions, moreover, neither of these methods appeared to make possible as much of a reduction in the manufacturing and storage costs of jigs, fixtures, and templates as did N/C. Along the same lines, N/C also promised to reduce more significantly the labor costs for toolmakers, machinists, and patternmakers. And, of course, the very large air force subsidization of N/C technology lured most manufacturers and users to where the action was. Yet there were still other, less practical, reasons for the adoption of N/C and the abandonment of record-playback, reasons that have more to do with the ideology of engineering than with economic calculations. However useful as a production technology, record-playback was considered quaint from the start, especially with the advent of N/C. N/C was always more than a technology for cutting metals, especially in the eyes of its MIT designers, who knew little about metalcutting: it was a symbol of the computer age, of mathematical elegance, of power, order, and predictability, of continuous

* This history is based upon interviews with Hans Trechsel, designer of Gisholt's "Factrol" system, and interviews and correspondence with participating engineering and sales personnel at GE (Schenectady), as well as articles in various engineering and trade journals.

flow, of remote control, of the automatic factory. Record-playback, on the other hand, however much it represented a significant advance on manual methods, retained a vestige of traditional human skills; as such, in the eyes of the future (and engineers always confuse the present and the future) it was obsolete.

The drive for total automation which N/C represented, like the drive to substitute capital for labor, is not always altogether rational. This is not to say that the profit motive is insignificant—hardly. But economic explanations are not the whole story, especially in cases where ample government financing renders cost-minimization less of an imperative. Here the ideology of control emerges most clearly as a motivating force, an ideology in which the distrust of the human agency is paramount, in which human judgment is construed as "human error." But this ideology is itself a reflection of something else: the reality of the capitalist mode of production. The distrust of human beings by engineers is a manifestation of capital's distrust of labor. The elimination of human error and uncertainty is the engineering expression of capital's attempt to minimize its dependence upon labor by increasing its control over production. The ideology of engineering, in short, mirrors the antagonistic social relations of capitalist production. Insofar as the design of machinery, like machine tools, is informed by this ideology, it reflects the social relations of production.* Here we will emphasize this aspect of the explanation—why N/C was developed and record-playback was not—primarily because it is the aspect most often left out of such stories.

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* It could be argued that control in the capitalist mode of production is not an independent factor (a manifestation of class conflict), but merely a means to an economic end (the accumulation of capital). Technology introduced to increase managerial control over the work force and eliminate pacing is, in this view, introduced simply to increase profits. Such reductionism, which collapses control and class questions into economistic ones, renders impossible any explanation of technological development in terms of social relations or any careful distinction between productive technology which directly increases output per person-hour and technology which does so only indirectly by reducing worker resistance or restriction of output. Finally, it makes it hard to distinguish a technology that reduces pacing from a gun in the service of union-busting company agents; both investments ultimately have the same effect and the economic results look the same on the balance sheet. As Jeremy Brecher reminds us, "The critical historian must go behind the economic category of cost-minimization to discover the social relations that it embodies (and conceals)" (1978).

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Ever since the nineteenth century, labor-intensive machine shops have been a bastion of skilled labor and the locus of considerable shop-floor struggle. Frederick Taylor introduced his system of scientific management in part to try to put a stop to what he called "systematic soldiering" (now called "pacing"). Workers practiced pacing for many reasons: to keep some time for themselves, to exercise authority over their own work, to avoid killing "gravy" piece-rate jobs by overproducing and risking a rate cut, to stretch out available work for fear of layoffs, to exercise their creativity and ingenuity in order to "make out" on "stinkers" (poorly rated jobs), and, of course, to express hostility to management (see articles by Roy; Mathewson 1969). Aside from collective cooperation and labor-prescribed norms of behavior, the chief vehicle available to machinists for achieving shop-floor control over production was their control over the machines. Machining is not a handicraft skill but a machine-based skill; the possession of this skill, together with control over the speeds, feeds, and motions of the machines, enables machinists alone to produce finished parts to tolerance (Montgomery 1976b). But the very same skills and shop-floor control that made production possible also make pacing possible. Taylor therefore tried to eliminate soldiering by changing the process of production itself, transferring skills from the hands of machinists to the handbooks of management; this, he thought, would enable management, not labor, to prescribe the details of production tasks. He was not altogether successful. For one thing, there is still no absolute science of metalcutting and methods engineers, time-study people, and Method Time Measurement (MTM) specialists—however much they may have changed the formal processes of machine-shop practice—have not succeeded in putting a stop to shop-floor control over production.*

Thus, when sociologist Donald Roy went to work in a machine shop in the 1940s, he found pacing alive and well. He recounts an incident that demonstrates how traditional patterns of authority rather than scientific management still reigned supreme:

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* The setting of rates on jobs in machine shops is still more of a guess than a scientific determination. This fact is not lost on machinists, as their typical descriptions of the methods-men suggests: "They ask their wives, they don't know; they ask their children, they don't know; so they ask their friends." Of course, this apparent and acknowledged lack of scientific certainty comes into play during bargaining sessions over rates, when "fairness" and power, not science, determine the outcome.

> "I want 25 or 30 of those by 11 o'clock," Steve the superintendent said sharply, a couple of minutes after the 7:15 whistle blew. I [Roy] smiled at him agreeably. "I mean it," said Steve, half smiling himself, as McCann and Smith, who were standing near us, laughed aloud. Steve had to grin in spite of himself and walked away. "What he wants and what he is going to get are two different things," said McCann. (1953:513)

Thirty years later, sociologist Michael Burawoy returned to the same shop and concluded, in his own study of shop-floor relations, that "in a machine shop, the nature of the relationship of workers to their machines rules out coercion as a means of extracting surplus" (1976).

This was the larger context in which the automation of machine tools took place; it should be seen, therefore, as a further managerial attempt to wrest control over production from the shop-floor work force. As Peter Drucker once observed, "What is today called automation is conceptually a logical extension of Taylor's scientific management" (1967:26). Thus it is not surprising that when Parsons began to develop his N/C "Cardomatic" system, he took care not to tell the union (the UAW) in his shop in Traverse City about his exciting new venture. At GE (Schenectady), a decade of work-stoppages over layoffs, rate cuts, speed-ups, and the replacement of machinists with less skilled apprentices and women during the war, culminated in 1946 in the biggest strike in the company's history, led by machinists in the United Electrical Workers (UE) and bitterly opposed by the GE Engineers' Association. GE's machine-tool automation project, launched by these engineers soon afterward, was secret, and although the project had strong management support, publicist Vonnegut recalled, with characteristic understatement, that "they wanted no publicity this time."*

During the first decade of machine-tool automation development, the aircraft industry—the major user of automatic machine tools—also experienced serious labor trouble as the machinists and auto workers competed to organize the plants. The postwar depression had created discontent among workers faced with layoffs, company claims of inability to pay, and massive downward reclassifications (Allen and Schneider 1956). Major strikes took place at Boeing, Bell Aircraft (Parsons' prime contractor), McDonnell Douglas, Wright Aeronautical, GE (Evandale) (jet engines), North American Aviation, and Republic Aircraft. It is not difficult, then, to explain the popularity among management and technical men of a November 1946 *Fortune* article entitled "Machines Without Men." Surveying the technological fruits of the war (sensing and measuring devices, servomechanisms, computers, etc.), two Canadian physicists promised that "these devices are not subject to any human limitations. They do not mind working around the clock. They never feel hunger or fatigue. They are always satisfied with working conditions, and never demand higher wages based on the company's ability to pay." In short, "they cause much less trouble than humans doing comparable work" (Leaver and Brown 1946:203).

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* Kurt Vonnegut, letter to author, February 1977.

One of the people who was inspired by this article was Lowell Holmes, the young electrical engineer who directed the GE automation project. However, in record-playback, he developed a system for replacing machinists that ultimately retained machinist and shop-floor control over production because of the method of tape preparation.* This "defect" was recognized immediately by those who attended the demonstration of the system; they showed little interest in the technology. "Give us something that will do what we say, not what we do," one of them said. The defects of record-playback were conceptual, not technical; the system simply did not meet the needs of the larger firms for managerial control over production. N/C did. "Managers like N/C because it means they can sit in their offices, write down what they want, and give it to someone and say, 'do it,' " the chief GE consulting engineer on both the record-playback and N/C projects explained. "With N/C there is no need to get your hands dirty, or argue" (personal interview). Another consulting engineer, head of the Industrial Applications Group which served as intermediary between the research department and sales department at GE (Schenectady) and a key figure in the development of both technologies, explained the shift from record-playback to N/C: "Look, with record-playback the control of the machine remains with the machinist—control of feeds, speeds, number of cuts, output; with N/C there is a shift of control to management. Management is no longer dependent upon the operator and can thus optimize the use of their machines. With N/C, control over the process is placed firmly in the hands of management—and why shouldn't we have it?" (personal interview). It is no wonder that at GE, N/C was often referred to as a management system, not as a technology of cutting metals.*

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* The fact that record-playback lends itself to shop-floor control of production more readily than N/C is borne out by a study of N/C in the United Kingdom done by Erik Christiansen in 1968. Only in those cases where record-playback or plugboard controls were in use (he found six British-made record-playback jig borers) did the machinist keep the same pay scale as with conventional equipment and retain control over the entire machining process. In Christiansen's words, record-playback (and plugboard programming) "mean that the shop floor retains control of the work cycle through the skill of the man who first programmed the machine" (1968:27, 31).

Numerical control dovetailed nicely with larger efforts to computerize company operations, which also entailed concentrating the intelligence of manufacturing in a centralized office. In the intensely anti-Communist 1950s, moreover, as one former machine-tool design engineer has suggested, N/C looked like a solution to security problems, enabling management to remove blueprints from the floor so that subversives and spies couldn't get their hands on them. N/C also appeared to minimize the need for costly tooling and it made possible the cutting of complex shapes that defied manual and tracer methods, and reduced actual chip-cutting time. Equally important, however, N/C replaced problematic time-study methods with "tape time"—using the time it takes to run a cycle as the base for calculating rates—replaced troublesome skilled machinists with more tractable "button-pushers," and eliminated once and for all the problem of pacing. If, with hindsight, N/C seems to have led to organizational changes in the factory, changes which enhanced managerial control over production, it is because the technology was chosen, in part, for just that purpose. This becomes even clearer when we look at how the chosen technology was deployed.

Choice in Deployment: Managerial Intentions

There is no question but that management saw in N/C the potential to enhance their authority over production and seized upon it, despite questionable cost effectiveness.† Machine-tool conducted the early studies on the economics of N/C focused on the savings in cutting time and waxed eloquent about the new revolution. At the same time, however, they warned that the key to the economic viability of N/C was a reduction in programming (software) costs. Machine-tool company salesmen were not disposed to emphasize these potential drawbacks, though, and numerous users went bankrupt because they believed what they were told. In the early days, however, most users were buffered against such tragedy by state subsidy. Today, potential users are somewhat more cautious, and machine-tool builders are more restrained in their advertising, tempering their promise of economic success with qualifiers about proper use, the right lot and batch size, sufficient training, etc.

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* GE Company 1958. See also Forrester *et al.* 1955.

† The cost effectiveness of N/C depends upon many factors, including training costs, programming costs, computer costs, and the like, beyond mere time saved in actual chip-cutting or reduction in direct labor costs. The MIT staff who

For the independent investigator, it is extremely difficult to assess the economic viability of such a technology. There are many reasons for this. First, the data is rarely available or accessible. Whatever the motivation—technical fascination, keeping up with competitors, etc.—the purchase of new capital equipment must be justified in economic terms. But justifications are not too difficult to come by if the item is desired enough by the right people. They are self-interested anticipations and thus usually optimistic ones. More important, firms rarely conduct postaudits on their purchases, to see if their justifications were warranted. Nobody wants to document his errors and if the machinery is fixed in its foundation, that is where it will stay, whatever a postaudit reveals; you learn to live with it. The point here is that the economics of capital equipment is not nearly so tidy as economists would sometimes have us believe. The invisible hand has to do quite a bit of sweeping up after the fact.

If the data does exist, it is very difficult to get a hold of. Companies have a proprietary interest in the information and are wary about disclosing it for fear of revealing (and thus jeopardizing) their position vis à vis labor unions (wages), competitors (prices), and government (regulations and taxes). Moreover, the data, if it were accessible, is not all tabulated and in a drawer somewhere. It is distributed among departments, with separate budgets, and the costs to one are the hidden costs to the others. Also, there is every reason to believe that the data that does exist is self-serving information provided by each operating unit to enhance its position in the firm. And, finally, there is the tricky question of how "viability" is defined in the first place. Sometimes, machines make money for a company whether they were used productively or not.

The purpose of this aside is to emphasize the fact that "bottom-line" explanations for complex historical developments, like the introduction of new capital equipment, are never in themselves sufficient, nor necessarily to be trusted. If a company wants to introduce something new, it must justify it in terms of making a profit. This is not to say, however, that profit making was its real (or, if so, its only) motive or that a profit was ever made. In the case of automation, steps are taken less out of careful calculation than on the faith that it is always good to replace capital with labor, a faith kindled deep in the soul of manufacturing engineers and managers (as economist Michael Piore, among others, has shown. See, for example, Piore 1968). Thus, automation is driven forward, not simply by the profit motive, but by the ideology of automation itself, which reflects the social relations of production

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builders and control manufacturers, of course, also promoted their wares along these lines; well attuned to the needs of their customers, they promised an end to traditional managerial problems. Thus the president of the Landis Machine Company, in a trade journal article entitled "How Can New Machines Cut Costs?" stressed the fact that "with modern automatic controls, the production pace is set by the machine, not by the operator" (Stickell 1960:61). The advertising copy of the MOOG Machine Company of Buffalo, New York, similarly described how their new machining center "has allowed management to plan and schedule jobs more effectively," while pointing out, benevolently, that "operators are no longer faced with making critical production decisions" (MOOG Hydra-Point News 1975).

Machine-tool and control system manufacturers peddled their wares and the trade journals, forever in search of advertisements, echoed their pitch. Initially, potential customers believed the hype; they very much wanted to. Earl Lundgren, the sociologist who surveyed N/C user plants in the 1960s concluded that the "prime interest in each subject company was the transfer of as much planning and control from the shop to the office as possible" and that management believed that "under numerical control the operator is no longer required to take part in planning activities" (Lundgren 1969).

In my own survey (1977–1978) of twenty-five plants in the Midwest and New England—including manufacturers of machine tools, farm implements, heavy construction equipment, jet engines and aircraft parts, and specialized industrial machinery—I observed the same phenomenon. Everywhere, management initially believed in the promises of N/C promoters and attempted to remove all decision making from the floor and assign unskilled people to N/C machines; to substitute "tape time" for problematic time studies to set base rates for piecework and measure output quotas; and to tighten up authority by concentrating all mental activity in the office and otherwise to extend detail control over all aspects of the production process.

This is not to say, however, that I drew the same conclusions that Lundgren did in his earlier survey. Characteristically, for an industrial sociologist, he viewed such changes as requirements of the new technology whereas, in reality, they reflected simply the possibilities of the technology which were "seized upon" (to use Harry Braverman's phrase) by management to realize particular objectives, social as well as technical. There is nothing inherent in N/C technology, however, that makes it necessary to assign *programming and machine tending to different* people (that is, to management and workers, respectively); the technology merely makes it possible (Braverman 1974:199). Management philosophy and motives—reflecting the social relations of the capitalist mode of production in general and a historically specific economic and political context in particular—make it necessary that the technology be deployed in this way.

One illustration of managerial choice in machine deployment is provided by the experience of a large manufacturing firm near Boston. In 1968, owing to low worker morale, turnover, absenteeism, and the general unreliability of programming and machinery, the company faced what it termed a "bottleneck" in its N/C lathe section. Plant managers were frantic to figure out a way to achieve the expected output from this expensive equipment. In that prosperous and reform-minded period, they decided upon a job enlargement/enrichment experiment wherein machine operators would be organized into groups and their individual tasks extended. Although it was the hope of the company that such a reorganization would boost the morale of the men on the floor and motivate them to "optimize the utilization" of the machinery, the union was at first reluctant to cooperate, fearing a speed-up. The company was thus hard pressed to secure union support for their program and instituted a bonus for all participants. At one of the earliest management-union meetings on the new program, the company spokesman began his discussion of the job-enlargement issue with the question (and thinly veiled threat), "Should we make the hourly people button-pushers or responsible people?" Given the new technology, management believed they now had the choice, and, given the pressure of unusual circumstances, they were prepared to exercise it in what they understood to be an atypical way.*

* This experiment was relatively successful, but short-lived. Attracted to the program by the bonus, the reorganized work groups soon grew accustomed to the new conditions: no foremen or punch clock, their own tool crib, their own scheduling of parts through the shop, and even some training in programming. Morale improved and turnover, absenteeism, and the scrap-rate declined accordingly. However, managerial enthusiasm for the experiment soon waned, and, after only a few half-hearted years, it was unilaterally called off. The company claimed that the union's desire to extend the experiment to other areas of the shop and to other plants within the same corporation threatened to make

A second illustration of the managerial imperative behind technological determinism is provided in an interview I had with two shop managers in a plant in Connecticut. Here, as elsewhere, much of the N/C programming is relatively simple, and I asked the men why the operators couldn't do their own programming. At first they dismissed the suggestion as ridiculous, arguing that the operators would have to know how to set feeds and speeds, that is, be industrial engineers. I pointed out that the same people probably set the feeds and speeds on conventional machinery, routinely making adjustments on the process sheet provided by the methods engineers in order to make out. They nodded. They then said that the operators couldn't understand the programming language. This time I pointed out that the operators could often be seen reading the mylar tape—twice-removed information describing the machining being done—in order to know what was coming (for instance, to anticipate programming errors that could mess things up). Again, they nodded. Finally they looked at each other, smiled, and one of them leaned over and confided, "We don't want them to." Here is the reality behind technological determinism in deployment.

Reality on the Shop Floor

Although the evolution of a technology follows from the social choices that inform it, choices which mirror the social relations of production, it would be an error to assume that in having exposed the choices, we can simply deduce the rest of reality from them. Reality cannot be extrapolated from the intentions that underlie the technology any more than from the technology itself.[*] Desire is not identical to satisfaction.

"In the conflict between the employer and employed," John G. Brooks observed in 1903, "the 'storm centre' is largely at this point where science and invention are applied to industry."[†] It is

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the program too expensive since an extension of the experiment meant also an extension of the bonus. The union business agent, formerly a shop steward in the experimental program and one of its stauchest supporters, explained the termination in another way: the company was losing control over the work force.

[*] This is an error that Braverman tended to make in discussing N/C.

[†] Cited in D. Montgomery (unpublished: Ch. 4, p. 1).

here that the reality of N/C was hammered out, where those who chose the technology finally came face-to-face with those who did not.

The introduction of N/C was not uneventful, especially in plants where the machinists' unions had a long history. Work stoppages and strikes over rates for the new machines were common in the 1960s, as they still are today. At GE, for example, there were strikes at several large plants and the entire Lynn, Massachusetts plant was shut down for a month during the winter of 1965. There are also less overt indications that management dreams of automatic machinery and a docile, disciplined work force but they have tended to remain just that.†

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† Perhaps the single most important, and difficult, task confronting the critical student of such rapidly evolving technologies as N/C is to try to disentangle dreams from realities, a hoped-for future from an actual present. The two realms are probably nowhere more confused than in the work of technologists. Thus, criticism of existing, or past, realities are typically countered with allusions to a less problematic future; the present is always the "debugging phase," the transition, at the beginning of the "learning curve"—merely a prelude to the future. As such, it is immune from scrutiny and criticism. To argue, as we do here, that N/C machinery does not run by itself or that mere "button-pushers" cannot produce good parts consistently on N/C, invites the rebuffs of those in the know, who refer to the automatic loading of N/C machines by the Unimate robots, to Flexible Manufacturing Systems (FMS) that tie any number of machines together with an automatic transfer line, to adaptive controls with sensors that automatically correct for tool wear and rough castings and the like, or to Direct Numerical Control systems (DNC) which centralize control over a whole plant of N/C equipment through one computer. Three important things must be kept in mind when dealing with such counterarguments.

First, technical people, it must be remembered, always have their eyes on the future—it is their job; they live in the state-of-the-art world which often has very little connection with industrial reality. Thus, it is hardly surprising that technical forecasters of the late 1950s predicted that by now at least 75 percent of machine tools in this country would be N/C (it is less than 2 percent), and that we would be seeing fully automatic metalworking factories (there are none). There is no better reason to believe the engineering and trade journals today, much less the self-serving forecasts of manufacturing engineers. All too often, social analysts merely echo these prophets, extrapolating wonderful or woeful consequences of projected technological changes without paying the slightest attention to the mundane vicissitudes of historical experience, or industrial practice. To them, the critic must respond: look again.

Second, judging from past experience, there is little reason simply to assume that the new experimental or demonstration systems will actually function on the shop floor as intended, much less perform economically. This author has visited

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Here we will examine briefly three of management's expectations: the use of "tape time" to set rates; the deskilling of machine operators; and the elimination of pacing.

Early dreams of using tape time to set base rates and measure performance and output proved fanciful. As one N/C operator observed, while rates on manual machines were sometimes too high, they were usually within a reasonable range, whereas the rates on N/C were "out of all relation to reality—ridiculously high; N/C's were supposed to be like magic but all you can do automatically on them is produce scrap." The machines, contrary to their advertisements, could not be used to produce parts

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four plants in the United States with FMS systems and found their economic justifications suspect, their down time excessive, and their reliability heavily dependent upon a highly skilled force of computer operators, system attendants, and maintenance men; there was also little sign of further development. Adaptive systems, under development at Cincinnati Milacron, are still in an experimental stage; when placed on the shop floor, these even more complex and sensitive pieces of machinery are bound to produce more maintenance problems than they solve. DNC is simply another name for the automatic factory, the supreme fantasy of the industrial technocrats, now heralded by self-serving computer jocks, supported by beleaguered corporate managers (whose far-sightedness is more rhetorical than real), and, as usual, funded by the military (in this case, the air force ICAM program).

Third, the ultimate viability of these technologies under the present mode of production depends, in the final analysis, upon the political and economic conditions that prevail and upon the relative strengths of the classes in their struggle over the control of production. To assume simply that the future will be what the designers and/or promoters of these technologies think it will be, would be to beg all of the questions being raised here, to ratify, out-of-hand, a form of technological determinism. Further, it would be to deny the realm of freedom that is being described, a freedom which could result not only in the delaying or subverting of these technologies (and thus the purposes they embody)—allowing for more time to struggle for greater freedom—but also in the fundamental reshaping of their design and use to meet ends other than simple capital accumulation and the extension of managerial and corporate power. See, for example, the discussion of Computer Numerical Control (CNC) in the final section on "alternative realities."

In short, a facile reference to the future is the educated habit of technical people in our society, people who are quite often seriously (and sometimes dangerously) ignorant of the past and mistaken about the present. To adopt their habit would be to suspend judgment (or, rather, yield to their judgment), to forego the critical, concrete, historical examination and assessment of the present situation, which alone can guide us intelligently into the still clouded future.

to tolerance without the repeated manual intervention of the operator in order to make tool offset adjustments, correct for tool wear and rough castings, and correct programming errors (not to mention machine malfunctions, such as "random holes" in drills and "plunges" in milling machines, often attributable to overheating). As the N/C operator just quoted explained, in a response to a *New York Times* article on the wonders of computer-based metalworking:

> Cutting metals to critical tolerances means maintaining constant control of a continually changing set of stubborn, elusive details. Drills run. End mills walk. Machines creep. Seemingly rigid metal castings become elastic when clamped to be cut, and spring back when released so that a flat cut becomes curved, and holes bored precisely on location move somewhere else. Tungsten carbide cutters imperceptibly wear down, making the size of a critical slot half a thousandth too small. Any change in any one of many variables can turn the perfect part you're making into a candidate for a modern sculpture garden, in seconds. Out of generations of dealing with the persistent, ornery problems of metal cutting comes the First Law of Machining: "Don't mess with success." (Tulin 1978:16)

In reality, N/C machines do not run by themselves—as the United Electrical Workers argued in its 1960 *Guide to Automation*, the new equipment, like the old, requires a spectrum of manual intervention and careful attention to detail, depending upon the machine, the product, and so on. The fiction that the time necessary to do a job could be determined by simply adding a standard factor or two (for setup, breaks, etc.) to the tape (cycle) time, was exploded early on, and with it hope of using the tape to measure performance (although some methods people still try).

The deskilling of machine operators has also, on the whole, not taken place as expected, for two reasons. First, as mentioned earlier, the assigning of labor grades and thus rates to the new machinery was, and is, a hotly contested and unresolved issue in union shops. Second, in union and nonunion shops alike, the determination of skill requirements for N/C must take into account the actual degree of automation and reliability of the machinery. Management has thus had to have people on the machines who know what they are doing simply because the machines (and programming) are not totally reliable; they do not run by themselves and produce good finished parts. Also, the machinery is still very expensive (even without microprocessors) and thus so is a machine smash-up. Hence, while it is true that many manufacturers initially tried to put unskilled people on the new equipment, they rather quickly saw their error and upgraded the classification. (In some places the most skilled people were put on the N/C machines and given a premium but the lower formal classifications were retained, presumably in the hope that someday the skill requirements would actually drop to match the classification—and the union would be decertified.) The point is that the intelligence of production has neither been built entirely into the machinery nor been taken off the shop floor. It remains in the possession of the work force.*

This brings us, once again, to the question of shop-floor control. In theory, the programmer prepares the tape (and thus sets feeds and speeds, thereby determining the rate of production), proofs it out on the machine, and then turns the show over to the operator, who from then on simply presses start and stop buttons and loads and unloads the machine (using standard fixtures). This rarely happens in reality, as was pointed out above. Machining to tolerances generally requires close attention to the details of the operation and frequent manual intervention through manual feed and speed overrides. This aspect of the technology, of course, reintroduces the control problem for management. Just as in the conventional shop, where operators are able to modify the settings specified on the worksheet (prepared by the methods engineer) in order to restrict output or otherwise "make out" (by running the machine harder), so in the N/C shop the operators are able to adjust feeds and speeds for similar purposes.

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* The shortage of skilled manpower has always been cited by managers and technical people as a justification for the introduction of labor-saving technologies like N/C. Rarely, however, is the shortage actually demonstrated or explained in any compelling way; it remains a necessary and unquestioned ideological prop. For a manpower shortage is a relative thing; relative to new air force and aircraft industry requirements in the cold war, there was a perceived shortage. But, given that shortages are only perceived in relation to a present or future need, they are predictable; they are not natural phenomena but socially created ones, remediable through training programs and sufficient monetary and other incentives. (This author remembers, for example, that not so long ago he went to college on loan programs created to deal with a recognized shortage of college teachers, relative to a vastly expanding educational system.) Thus, when managers introduce N/C because of the impending retirement of the last generation of skilled machinists, we must ask, where are their replacements? Why have apprenticeship programs been eliminated or shortened? Why do vocational courses habituate young people to "semiskilled" work in the name of training for a craft? The answer is that the shortage is, in reality, created to complement the new technology, not the other way around. Fortunately for capital, however, the skill is not entirely eliminated, however "unskilled" the classification; passed on informally and on the job, it remains on the shop floor. If it wasn't there, finished parts would never make it out the door.

Thus, if you walk into a shop you will often find feed-rate override dials set uniformly at, say, 70 or 80 percent of tape-determined feed rate. In some places this is called the "70 percent syndrome"; everywhere it is known as pacing. To combat it, management sometimes programs the machines at 130 percent, and sometimes actually locks the overrides altogether to keep the operators out of the "planning process." This in turn gets management into serious trouble since the interventions are required to get the parts out the front door.

It is difficult to assess to what extent the considerable amount of intervention is attributable to the inherent unreliability of the complex equipment itself, but it is certainly true that the technology develops shortcomings once it is placed on the shop floor, whether or not they were there in the original designs. Machines often do not do what they are supposed to do and down time is still excessive. Technical defects, human errors, and negligence are acknowledged problems, and so is sabotage. "I don't care how many computers you have, they'll still have a thousand ways to beat you," lamented one manager of N/C equipment in a Connecticut plant. "When you put a guy on an N/C machine, he gets temperamental," another manager in Rhode Island complained. "And then, through a process of osmosis, the machine gets temperamental."

On the shop floor, it is not only the choices of management that have an effect. The same antagonistic social relations that, in their reflection in the minds of designers, gave issue to the new technology, now subvert it. This contradiction of capitalist production presents itself to management as a problem of "worker motivation," and management's acceptance of the challenge is its own tacit acknowledgment that it does not have shop-floor control over production, that it is still dependent upon the work force to turn a profit.

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Thus, in evaluating the work of those whose intentions to wrest control over production from the work force informed the design and deployment of N/C, we must take into account an article written by two industrial engineers in 1971 entitled "A Case for Wage Incentives in the N.C. Age." It makes it quite clear that the contradiction of capitalist production has not been eclipsed—computers or no computers:

> Under automation, it is argued, the machine basically controls the manufacturing cycle, and therefore the worker's role diminishes in importance. The fallacy in this reasoning is that if the operator malingers or fails to service the machine for a variety of reasons, both utilization and subsequent return on investment suffer drastically.
>
> Basic premises underlying the design and development of N.C. machines aim at providing the capability of machining configurations beyond the scope of conventional machines. Additionally, they "de-skill" the operator. Surprisingly, however, the human element continues to be a major factor in the realization of optimum utilization or yield of these machines. This poses a continuing problem for management, because a maximum level of utilization is necessary to assure a satisfactory return on investment. (Doring and Saling 1971:31)

The motivation problem boils down to this: What will a machine operator, "skilled" or "unskilled," do when he sees a $250,000 milling machine heading for a smash-up? He could rush to the machine and press the panic button, retracting the workpiece from the cutter or shutting the whole thing down, or he could remain seated and think to himself, "Oh, look, no work tomorrow." For management, the situation poses the dilemma faced by every capitalist, a contradiction succinctly, if inadvertently, expressed by another plant manager in Connecticut. With a colleague chiming in, he proudly described the elaborate procedure they had developed whereby every production change, even the most minor, had to be okayed by an industrial engineer. "We want absolutely no decision made on the floor," he insisted; no operator was to make any change from the process sheets without the written authorization of a supervisor. A moment later, however, looking out onto the floor from his glass-enclosed office, he reflected upon the reliability of the machinery, and the expense of parts and equipment, and emphasized, with equal conviction, that "We need guys out there who can think."

Alternative Realities

Shop-floor realities are determined by the social relations, as well as the technology, of production and, as we have seen, the latter is shaped by the former no less than the reverse. But thus far we have examined only the ways in which managerial intentions, introduced in the form of new technology, are subverted in practice; this is only part of the story, the part defined, in a restricted way, by social relations which assign to labor a "negative" role. Having had to adopt a defensive posture against a far more powerful adversary, the American trade union movement opted out of certain struggles (for instance, for the right to make production decisions, now an exclusive "management prerogative") in order to concentrate on and gain advantage in others (for example, job security, wages, benefits). Accordingly, when confronted with changing technology labor has generally limited its response to post-hoc resistance. This has meant, of course, that labor's choices have not been registered in the actual design and deployment stages and that, therefore, the technology does not reflect its interest. A more forward-looking and sophisticated labor movement, however, facing an intensified management drive toward rationalization and automation, could transcend this passive role and begin to act positively, demanding, and preparing itself for, a voice in design and deployment decisions. As one American N/C machine operator has argued:

> The introduction of automation means that our skills are being downgraded, and instead of having the prospect of moving up to a more interesting job, we now have the prospect of either unemployment or a dead-end job. [But] there are alternatives that the union can explore. We have to establish the position that the fruits of technological change can be divided up—some to the workers, not all to the management, as is the case today. We must demand that the machinist rise with the complexity of the machine. Thus, rather than dividing his job up, the machinist should be trained to program and repair his new equipment—a task well within the grasp of most people in the industry.
>
> Demands such as these strike at the heart of most management prerogative clauses which are in many collective-bargaining contracts. Thus, to deal with automation effectively, one has to strike another prime ingredient of business unionism: the idea of "let the management run the business." The introduction of N.C. equipment makes it imperative that we fight such ideas. (Emspak, unpublished)

The real potential of this challenge can perhaps best be illustrated by the existing variations in deployment of the latest generation of N/C machines, called Computer Numerical Control (CNC) systems. CNC machines come equipped with a small minicomputer control unit. With this addition, made feasible by the advent of microprocessors, it becomes possible to store the information from a dozen or so tapes right on the machine itself and then simply retrieve the right program to make a part. More important, the information from the tape can be manipulated and edited: the sequence of operations can be changed, and operations can be added or subtracted. After the changes are made and the parts are run, the machine can produce a "corrected" tape for permanent storage in the company library. With this technology, it becomes possible not only to edit tapes on the shop floor but to create them from scratch; in some systems, programs for even rather complex contours can be made right at the machine by either punching in the required information at a keyboard on the console (so-called manual data input—MDI) or by moving the machine itself to make the first part and entering the information after each operation. (This feature, of course, reintroduces the record-playback concept in an updated digitized form.)

Made possible by the revolution in microelectronics and introduced by machine-tool manufacturers in order to penetrate the vast job market (because it eliminates the overhead requirements of software preparation—the major obstacle for the job shop) and by large metalworking plants in order to get around insurmountable software programming problems (because it allows for easy tape correcting and editing), the new CNC technology lends N/C as never before to total shop-floor control.

Although the large metalworking plants in the United States are steadily introducing CNC equipment, the potential for shop-floor control is far from being realized. The GE plant in Lynn, Massachusetts, is a typical example. Here machine operators are not permitted to edit programs—much less to make their own—on the new CNC machines; quite often the controls are locked. Only supervisory staff and programmers are allowed to edit the programs. Managers are afraid of losing shop-floor control or confusing their tidy labor classification and wage system; programmers are afraid that operators lack the training and experience required for programming—an argument that has convinced at least some operators that these functions are beyond their intellectual grasp. The shortcomings of this system for the operators are obvious. Less obvious are the shortcomings for management: lower quality production and excessive machine down time. If the programs are faulty and the operator cannot (or is not allowed to) make the necessary adjustments, the parts produced will be faulty. If a machine goes down because of programming problems on the second and third shifts, when the programmers are not around, it is likely to be down for the night, with a corresponding loss in productivity.

The situation is quite different in the state-owned weapons factory in Kongsberg, Norway, a plant with roughly the same number of employees, a similar line of products (aircraft parts and turbines), a similar mix of commercial and military customers, and, most important, the same types of CNC machinery (although here they tend to be European-made rather than Japanese) as at GE.* But in Norway the operators routinely do all of the editing, according to their own criteria of safety, efficiency, quality, and convenience; they change the sequence of operations, add or subtract operations, and sometimes alter the entire structure of the program to suit themselves. When they are satisfied with a program and have finished producing a batch of parts, they press a button to generate a corrected tape which, after being approved by a programmer, is put into the library for permanent storage.

All operators are trained in N/C programming and, as a consequence, their conflicts with the programmers are reduced. One programmer—who, like most of his colleagues, had received his training in programming while still a machine operator—justified having any programmers at all by the fact that the programmer was a specialist and was thus more proficient (he also dealt directly with customers and did most of the APT programming of highly complex aircraft parts). Yet when asked if it bothered him to have his well-worked programs tampered with by the operators, he replied, without hesitation, that "the operator knows best: he's the one who has to actually make the part and is more intimately familiar with the particular safety and convenience factors; also, he usually best knows how to optimize the program for his machine."

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* The following discussion of the situation in Kongsberg, Norway, is based upon correspondence and personal contact with participants in the trade union participation project and a recent research visit to Scandinavia (October 1978).

This situation, it should be pointed out, is unusual even for Norway. It is the result of many factors. The Iron and Metalworkers' Union in Norway is the most powerful industrial union in the country and the local "club" in Kongsberg is a potent force in the industrial, political, and social life of Kongsberg, representing a cohesive and rather homogeneous working-class community. The factory is important in state policy, as a holding company in electronics, and is an important center of high technology engineering. Also, social democratic legislation in Norway has encouraged worker participation in matters pertaining to working conditions and has given unions the right to information. Most important, however, the local "club" has been involved for the last seven years in what has been called the "trade union participation project," an important development in workers' control which focuses upon the introduction of computer-based manufacturing technology.

In 1971, the Iron and Metalworkers' Union, faced with an unprecedented challenge of new computer-based information and control systems (for production, scheduling, inventory, etc., as well as machining), took steps to learn how to meet it. They succeeded in hiring, on a single-party basis (that is, without management collaboration), the government-run Norwegian Computing Center to research the new technology for them. As the direct result of this unprecedented effort, computer technology was demystified for the union, and the union—and labor in general—was demystified for the computer scientists at the Center; the union became more sophisticated about the technology and the technical people became more attuned to the needs and disciplines of trade unionists. In practical terms, the study resulted in the production of a number of textbooks on the new technology, written by and for shop stewards, the creation of a new union position, the "data shop steward," and, in time, the establishment of formal "data agreements" (between individual companies and their local "clubs" and between the national union and the employers' federation) which outlined the union's right to participate in decisions about technology.

The Kongsberg plant was the first site of such trade union participation. Here the data shop steward, a former assembly worker, is responsible for keeping abreast of and critically scrutinizing all new systems; another man is assigned the job of supervising the activity of the data shop steward to ensure that he doesn't become a "technical man," that is, captive either of the technology or of management and out of touch with the interests of the people on the shop floor. The responsibilities are enormous: this is not a situation in which union and management cooperate harmoniously, nor is it a management-devised job-enlargement scheme to motivate workers. The task of the data shop steward, and the union in general, is to engage, as effectively as possible, in a struggle over information and control, a struggle engaged in, with equal sophistication and earnestness, by the other side.

When management plans to introduce a new computer-based production system, for example, the union must assume as a matter of course (based upon long experience) that the proposed design reflects purposes that are not necessarily consonant with the interests of the workers. The data shop steward and his colleagues must learn about the system early enough, and investigate it thoroughly enough, to ensure that it contains no features that make possible, for example, the measurement of individual performance or any monitoring of shop-floor activities that would restrict worker freedom or control. As it turns out, all new systems invariably contain such features (since they are often camouflaged attempts to introduce control mechanisms that have been successfully resisted by the workers in other forms), and it is up to the union to identify them and demand that they be eliminated. It is the union's responsibility to its members, in short, to struggle to "recondition" the system so that it meets their own, as well as management's, specifications. At Kongsberg, for example, after a long battle, the union has succeeded in securing for all of the people on the shop floor complete access to the computer-based production and inventory systems. Just as CNC has made automatic machining more accessible to shop-floor control, so computer-integrated production systems have made it possible to eliminate certain managerial functions by simply extending the reach of the people on the shop floor. How this technology will actually be employed in a plant depends less upon any inherent nature of the technology than upon the particular manufacturing processes involved, the political and economic setting, and the relative power and sophistication of the parties engaged in the struggle over control of production.

The social relations of production shape the technology of production as much as the other way around. Given different social relations, one sees different designs, different deployment. Of course, these relations are themselves shaped by larger conditions—the political, economic, and cultural climate, the labor market, trade union traditions and strengths, international competition and the flow of investment capital. These factors always influence the conditions for struggle, define its constraints. But whatever the constraints, whatever the social conditions, the technological possibilities remain.

4

THE MATERIAL OF MALE POWER

C. COCKBURN

C. Cockburn, 'The material of male power', in D. MacKenzie & J. Wajcman (eds), *The Social Shaping of Technology: How the Refrigerator got its Hum*, Open University Press, Milton Keynes, 1985, pp. 125–46.

A skilled craftsman may be no more than a worker in relation to capital, but seen from within the working class he has been a king among men and lord of his household. As a high earner he preferred to see himself as the sole breadwinner, supporter of wife and children. As artisan he defined the unskilled workman as someone of inferior status, and would 'scarcely count him a brother and certainly not an equal' (Berg, 1979: 121). For any socialist movement concerned with unity in the working class, the skilled craftsman is therefore a problem. For anyone concerned with the relationship of class and gender, and with the foundations of male power, skilled men provide a fertile field for study.

Compositors in the printing trade are an artisan group that have long defeated the attempts of capital to weaken the tight grip on the labour process from which their strength derives. Now their occupation is undergoing a dramatic technological change initiated by employers. Introduction of the new computerized technology of photocomposition represents an attack on what remains of their control over their occupation and wipes out many of the aspects of the work which have served as criteria by which 'hot metal' composition for printing has been defined as a manual skill and a man's craft.[1]

In this paper I look in some detail at the compositors' crisis, what has given rise to it and what it may lead to in future. Trying to understand it has led me to ask questions in the context of socialist-feminist theory. These I discuss first, as preface to an account of key moments in the compositors' craft history. I then isolate the themes of *skill* and *technology* for further analysis, and conclude with the suggestion that there may be more to male power than 'patriarchal' relations.

Producing class and gender

The first difficulty I have encountered in socialist-feminist theory is one that is widely recognized: the problem of bringing into a single focus our experience of both class and gender. Our attempts to ally the Marxist theory of capitalism with the feminist theory of 'patriarchy' have till now been unsatisfactory to us (Hartmann, 1979a).

One of the impediments I believe lies in our tendency to try to mesh together two static structures, two hierarchical systems. In studying compositors I found I was paying attention instead to *processes*, the detail of historical events and changes, and in this way it was easier to detect the connexions between the power systems of class and gender. What we are seeing is *struggle that contributes to the formation of people within both their class and gender simultaneously*.

One class can only exist in relation to another. E. P. Thompson wrote 'we cannot have two distinct classes each with an independent being and then bring them into relationship with each other. We cannot have love without lovers, nor deference without squires and labourers.' Likewise, it is clear we cannot have masculinity without feminity: genders presuppose each other, they are relative. Again, classes are made in historical processes. 'The working class did not rise like the sun at an appointed time. It was present at its own making . . . Class is defined by men [sic] as they live their own history' (Thompson, 1963). The mutual production of gender should be seen as a historical process too.

So in this paper I set out to explore aspects of the process of mutual definition in which men and women are locked, and those (equally processes of mutual creation) in which the working class and the capitalist class are historically engaged. Capital and labour, through a struggle over the design and manipulation of technology that the one owns and the other sets in motion, contribute to forming each other in their class characters. Powerfully-organized workers forge their class identity vis-a-vis both capital and the less organized and less skilled in part through this same process. And men and women too are to some extent mutually defined as genders through their relation to the same technology and labour process. In neither case is it a balanced process. By owning the means of production the capitalist class has the initiative. By securing privileged access to capability and technology the man has the initiative. Each gains the power to define 'another' as inferior.[2] I will try to draw these occurrences out of the story of the compositors as I tell it.

Components of power

The second theoretical need which an examination of skilled workers has led me to feel is the need for a fuller conception of the material basis of male power, one which does not lose sight of its physical and socio-political ramifications in concentrating upon the economic.

As feminism developed its account of women's subordination one problem that we met was that of shifting out of a predominantly ideological mode and narrating also the concrete practices through which women are disadvantaged. Early literature relied on 'sexist attitudes' and 'male chauvinism' to account for women's position. Socialist feminists, seeking a more material explanation for women's disadvantage, used the implement of Marxist theory, unfortunately not purpose-designed for the job but the best that was to hand. The result was an account of the economic advantages to capital of women as a distinct category of labour and their uses as an industrial reserve army. The processes of capitalism seemed to be producing an economic advantage to men which could be seen uniting with their control over women's domestic labour to form the basis of their power.[3]

Many feminists, however, were dissatisfied with what seemed a narrow 'economism' arising from Marx (or through mis-interpretation of Marx according to the point of view). The ideological vein has been more recently worked with far more sophistication than before, in different ways, by Juliet Mitchell on the one hand and Rosalind Coward on the other (Mitchell, 1975; Coward, 1978). But, as Michele Barrett has pointed out, while 'ideology is an extremely important site for the construction and reproduction of women's oppression . . . this ideological level cannot be dissociated from economic relations' (Barrett, 1980).

There is thus a kind of to-ing and fro-ing between 'the ideological' and 'the economic', neither of which gives an adequate account of male supremacy or female subordination. The difficulty lies, I believe, in a confusion of terms. The proper complement of *ideology* is not the *economic*, it is the *material*.[4] And there is more to the material than the economic. It comprises also the *socio-political* and the *physical*, and these are often neglected in Marxist–feminist work.

An instance of the problems that arise through this oversight is Christine Delphy's work, where a search for a 'materialist' account of women's subordination leads her to see marriage in purely economic terms and domestic life as a mode of production, an interpretation which cannot deal with a large area of women's circumstances (Delphy, 1977).

It is only by thinking with the additional concepts of the socio-political and the physical that we can begin to look for material instances of male domination beyond men's greater earning power and property advantage. The socio-political opens up questions about male organization and solidarity, the part played by institutions such as church, societies, unions and clubs for instance.[5] And the physical opens up questions of bodily physique and its extension in technology, of buildings and clothes, space and movement. It allows things that are part of our practice ('reclaiming the night', teaching each other manual skills) a fuller place in our theory.

In this account I want to allow 'the economic' to retire into the background, not to deny its significance but in order to spotlight these other material instances of male power. The socio-political will emerge in the shape of the printing trade unions and their interests and strategies. The physical will also receive special attention because it is that which I have found most difficult to understand in the existing framework of Marxist-feminist thought. It finds expression in the compositor's capability, his dexterity and strength and in his tools and technology.

One further prefatory note is needed. In 1970, when Kate Millett and Shulamith Firestone, in their different ways, pinned down and analysed the system of male domination they spoke to the anger that many women felt (Millett, 1971; Firestone, 1971). But many feminists were uneasy with the essentialism inherent in their view, and especially the biological determinism of Firestone and its disastrous practical implications.

Marxist-feminist theory has consequently tended to set on one side the concept of the superior physical effectivity of men, to adopt a kind of agnosticism to the idea, on account of a very reasonable fear of that biologism and essentialism which would nullify our struggle. I suggest however that we cannot do without a politics of physical power and that it need not immobilize us. In this article I use the term physical power to mean both corporal effectivity (relative bodily strength and capability) and technical effectivity (relative familiarity with and control over machinery and tools).

To say that most men can undertake feats of physical strength that most women cannot is to tell only the truth. Likewise it is true to say that the majority of men are more in their element with machinery than the majority of women. These statements are neither biologistic nor essentialist. Physical efficiency and technical capability do not belong to men primarily by birth, though DNA may offer the first step on the ladder. In the main they are appropriated by males through childhood, youth and maturity. Men's socio-political and economic power enables them to do this. In turn, their physical presence reinforces their authority and their physical skills enhance their earning power.

Ann Oakley, among others, has made the fruitful distinction between biologically-given sex (and that not always unambiguous) and culturally constituted gender, which need have little correlation with sex but in our society takes the form of a dramatic and hierarchical separation (Oakley, 1972).

The part of education and that of child-rearing in constituting us as masculine and feminine *in ideology* is the subject of an extensive literature (e.g. Wolpe, 1978; Belotti, 1975). But there is evidence to show that *bodily difference* is also largely a social product. With time and work women athletes can acquire a physique which eclipses the innate differences between males and females (Ferris, 1978). Height and weight are correlated with class, produced by different standards of living, as well as with gender.[6] Boys are conditioned from childhood in numberless ways to be more physically effective than girls. They are trained in activities that develop muscle, they are taught to place their weight firmly on both feet, to move freely, to use their bodies with authority. With regard to females they are socialized to seize or shelter them and led to expect them in turn to yield or submit.

While so much of the imbalance of bodily effectiveness between males and females is produced through social practices it is misguided to prioritize that component of the difference that may prove in the last resort to be inborn.[7] More important is to study the way in which a small physical *difference* in size, strength and reproductive function is developed into an increasing relative physical *advantage* to men and vastly multiplied by differential access to technology. The process, as I will show, involves several converging practices: accumulation of bodily capabilities, the definition of tasks to match them and the selective design of tools and machines. The male physical advantage of course interacts with male economic and socio-political advantage in mutual enhancement.

The appropriation of muscle, capability, tools and machinery by men is an important source of women's subordination, indeed it is part of the process by which females are constituted as women. It is a process that is in some ways an analogue of the appropriation of the means of production by a capitalist class, which thereby constituted its complementary working class. In certain situations and instances, as in the history of printers, the process of physical appropriation (along with its ideological practices) has a part in constituting people within their class and gender simultaneously.

The hand compositor: appropriation of technique

Letterpress printing comprises two distinct technological processes, composing and printing. Before the mechanization of typesetting in the last decade of the nineteenth century compositors set the type by hand, organizing metal pieces in a 'stick', and proceeded to assemble it into a unified printing surface, the 'forme', ready for the printer to position on the press, coat with ink and impress upon paper.

The hand compositor, then, had to be literate, to be able to read type upside down and back to front, with a sharp eye for detail. He had to possess manual dexterity and have an easy familiarity with the position of letters in the 'case'. He had to calculate with the printers' 'point' system of measurement. Furthermore he had to have a sense of design and spacing to enable him to create a graphic whole of the printed page, which he secured through the manipulation of the assembled type, illustrative blocks and lead spacing pieces. The whole he then locked up in a forme weighing 50 lbs or more. This he would lift and move to the proofing press or bring back to the stone for the distribution of used type. He thus required a degree of strength and stamina, a strong wrist, and, for standing long hours at the case, a sturdy spine and good legs.

The compositor used his craft to secure for himself a well-paid living, with sometimes greater and sometimes less success depending on conditions of trade. Through their trade societies (later unions) compositors energetically sought to limit the right of access to the composing process and its equipment to members of the society in a given town or region, blacking 'unfair houses' that employed non-society men.

Comps deployed all the material and ideological tactics they could muster in resistance to the initiatives of capital in a context of the gradual, though late, industrialization of printing. Capitalists continually aimed for lower labour costs, more productive labour processes, the 'real subordination' of labour. Their two weapons were the mobilization of cheap labour and the introduction of machinery. They repeatedly assaulted the defences of the comps' trade societies. The organized, skilled men saw their best protection against capital to lie in sharply differentiating themselves from the all-but-limitless population of potential rivals for their jobs, the remainder of the working class.

They sought to control the numbers entering the trade and so to elevate their wage-bargaining position by a system of formal apprenticeship. They tried to limit the number of apprentices through an agreed ratio of boys to journeymen and to keep the period of apprenticeship as long as possible. The introduction of unapprenticed lads, 'the many-headed monster', the 'demon of cheap boy labour' was always a source of fear to compositors. Comps' jobs were kept within the class fraction by the custom of limiting openings wherever possible to members of existing printer families.

Thus the struggles over physical and mental capability and the right of access to composing equipment was one of the processes in which fractions of classes were formed in relation to each other.

How did women enter this story? The answer is, with difficulty. Women and children were drawn into industrial production in many industries in the first half of the nineteenth century but in printing their entry was almost entirely limited to the bookbinding and other low-paid finishing operations held to require no skill. Girls were not considered suitable for apprenticeship. Physical and moral factors (girls were not strong enough, lead was harmful to pregnancy, the social environment might be corrupting) were deployed ideologically in such a way that few girls would see themselves as suitable candidates for apprenticeship. A second line of defence against an influx of women was of course the same socio-political controls used to keep large numbers of boys of the unskilled working class from flooding the trade.

Women who, in spite of these barriers, obtained work as non-society compositors were bitterly resisted and their product 'blacked' by the society men, i.e. work typeset by women could not be printed. Their number remained few therefore (Child, 1967). After 1859 a few small print shops were organized by philanthropic feminists to provide openings for women. It is worth noting that these enterprises did prove that women were in fact physically capable, given training and practice, of typesetting and imposition, though they did not work night shifts and male assistants were engaged to do the heavy lifting and carrying. These projects were dismissed by the men as 'wild schemes of social reformers and cranks'.[8]

The process of appropriation of the physical and mental properties and technical hardware required for composing by a group of men, therefore, was not only a capitalist process of class formation, as noted above, but also a significant influence in the process of gender construction in which men took the initiative in constituting themselves and women in a relation of complementarity and hierarchy.

The mechanization of typesetting: appropriation of the machine

The compositors' employers had for years sought to invent a machine that could bypass the labour-intensive process of hand typesetting. They hoped in so doing not only to speed up the process but to evade the trade societies' grip on the craft, introduce women and boys and thus bring down the adult male wage. The design of such a machine proved an intractable problem. Though various prototypes and one or two production models were essayed in the years following 1840, none were commercially successful. It was only when highspeed rotary press technology developed in the 1880s that typesetting became an intolerable bottleneck to printing and more serious technological experiment was undertaken. Among the various typesetting machines that then developed, the overwhelmingly successful model was the Linotype. It continued in use almost unchanged for sixty or seventy years.

The Linotype was not allowed to replace the hand typesetter without a struggle.[9] The men believed the Iron Comp would mean mass unemployment of society members. They did not (as an organized group) reject the machine out of hand, however. Their demand was the absolute, exclusive right of hand comps to the machine and to improved earnings. Their weapons were disruption, blacking and deliberate restriction of keyboard speeds. The outcome of the struggle was seen finally by both print employers and compositors as a moderate victory for both sides. There was unemployment of hand compositors for a few years in the mid-nineties, but with the upturn of business at the end of the Great Depression the demand for print grew fast and the demand for typesetters with it. Indeed, the first agreement between the London Society of Compositors (LSC) and the employers on the adaptation of the London Scale of Prices to Linotype production was a disastrous error for the capitalists, who had underestimated the productive capacity of their new force of production and overestimated the strength of the organized comps. The bosses only began to share fully in the profits from their invention when the agreement was revised in 1896. A lasting cost to the comps was an increasing division of labour between the two halves of their occupation: typesetting and the subsequent composing process. They did succeed however in continuing to encompass both jobs within the unitary craft and its apprenticeship as defined by their societies.

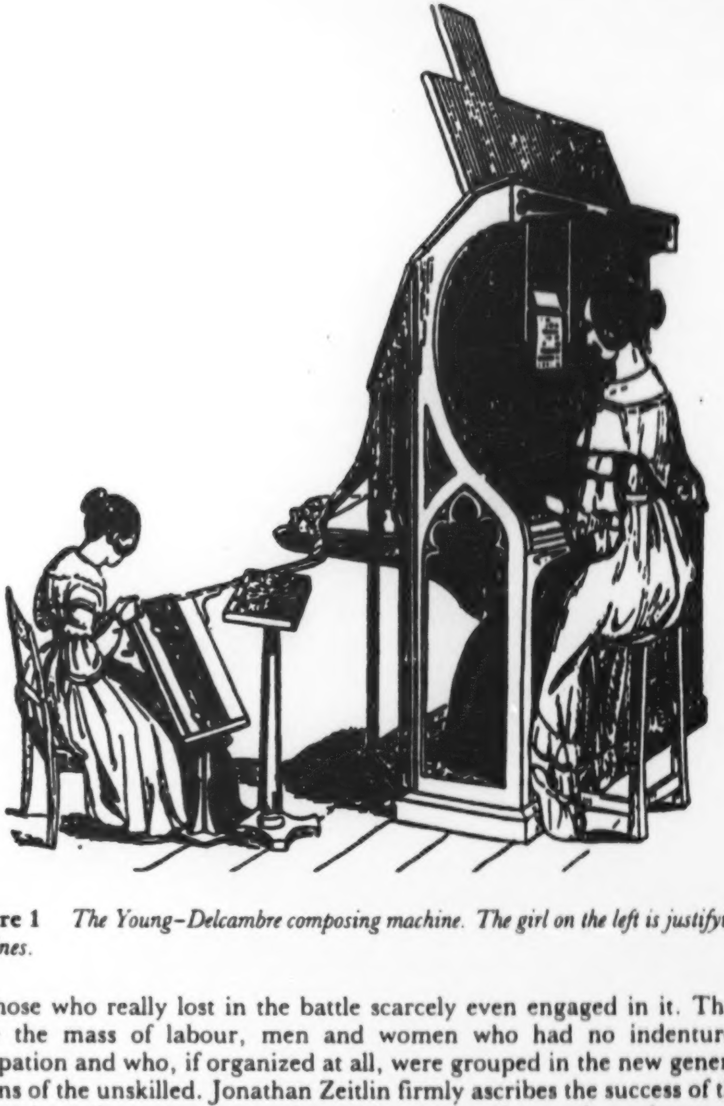

Figure 1 *The Young–Delcambre composing machine. The girl on the left is justifying the lines.*

Those who really lost in the battle scarcely even engaged in it. They were the mass of labour, men and women who had no indentured occupation and who, if organized at all, were grouped in the new general unions of the unskilled. Jonathan Zeitlin firmly ascribes the success of the compositors (in contrast to engineers) in routing the employers' attempt to break their control of their craft in the technological thrust of the late nineteenth century to the former's success in ensuring that during the preceding decades no unskilled or semi-skilled categories of worker had been allowed to enter the composing room to fill subordinate roles (Zeitlin, 1981). And the incipient threat from women had been largely averted by the time the Linotype was invented. An exception was a pocket of female compositors in Edinburgh who had entered the trade at the time of a strike by the men in 1872 and had proved impossible to uproot.

A more sustained attempt was made by employers ten years later to introduce women to work on another typesetting process that was widely applied in the book trade: the Monotype. The Monotype Corporation, designers of the machine, in contrast to the Linotype Company Ltd., opened the way to a possible outflanking of the skilled men by splitting the tasks of keyboarding and casting into two different machines. Men retained unshaken control of the caster, but an attempt was made by employers to introduce women onto the keyboards, which had the normal typewriter lay.

In 1909–10 the compositors' societies organized a campaign, focussing on Edinburgh, to eliminate women from the trade once and for all. They succeeded in achieving a ban on female apprentices and an agreement for natural wastage of women comps and operators. This male victory was partly due to an alliance between the craft compositors and the newly organized unions of the unskilled men in the printing industry (Zeitlin, 1981).

That there were large numbers of women, literate, in need of work and eminently capable of machine typesetting at this time is evidenced by the rapid feminization of clerical work that accompanied the introduction of the office typewriter, in a situation where the male incumbent of the office was less well organized to defend himself than was the compositor (Davies, 1979). Men's socio-political power, however, enabled them to extend their physical capabilities in manual typesetting to control of the machine that replaced it. (The gender-bias of typesetting technology is discussed further below.) The effect has been that women's participation in composing work, the prestigious and better-paid aspect of printing, was kept to a minimum until the present day, not excluding the period of the two World Wars. The composing room was, and in most cases still is, an all-male preserve with a sense of camaraderie, pin-ups on the wall and a pleasure taken in the manly licence to use 'bad' (i.e. woman-objectifying) language.

Electronic composition: the disruption of class and gender patterns

In the half-century between 1910 and 1960 the printing industry saw relatively little technical change. Then, in the nineteen-sixties two big new possibilities opened up for capital in the printing industry as, emerging from post-war restrictions, it looked optimistically to expanding print markets. The first was web offset printing, with its potential flexibility and quality combined with high running speeds. The logical corollary was to

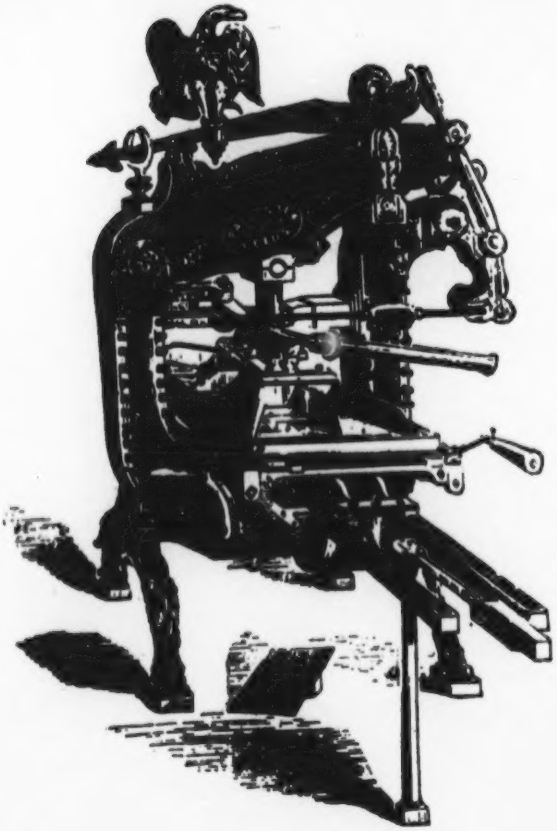

Figure 2 *A nineteenth-century iron hand-press.*

abandon the machine-setting of metal type and to take up the second component of 'the new technology': letter assembly on film or photographic paper by the techniques of computer-aided photocomposition. The new process began to make inroads in to the British printing industry in the late sixties and swept through the provincial press and general printing in the seventies. The last serious redoubt of hot metal typesetting and letterpress printing is now the national press in Fleet Street.

Photocomposition itself has gone through several phases of development. At first, the operation comprised a keyboarding process whereby the operator tapped a typewriter-style keyboard producing a punched paper tape. The operator worked 'blind', that is to say he saw no hard copy of his work as he produced it. The 'idiot tape' was fed into a computer which read it, made the subtle line-end decisions formerly the responsibility of the operator and output clean tape. This second tape drove a photosetter, each impulse producing a timed flash of light through a photographic image on a master disc or drum. The result was a succession of characters laid down on film or bromide paper. The columns of text were taken by the compositor, cut up, sorted and pasted in position on a prepared card, later to be photographed as a whole and reproduced on a printing plate.

In the latest electronic composing technology there is no such photomatrix of characters. The computer itself holds instructions that enable it to generate characters, in an almost limitless range of type faces and sizes and at enormously rapid speeds, on the face of a cathode ray tube. The inputting operation is performed with a keyboard associated with a video display unit on which the operator can assist computer decisions and 'massage' the copy into a desired order before committing it to the computer memory. The matter is transmitted direct from computer to photosetter and may now be produced in complete sections as large as a full newspaper page, making paste-up unnecessary.

The process is clearly seen by capital as a means of smashing the costly craft control of the compositor. The system is greatly more productive and requires less manpower. It would require less still if operated in the manner for which it is designed, i.e. avoiding two keyboarding processes by having typists, journalists, editors and authors key matter direct onto the computer disc for editing on screen and thence to direct output.

The work is much lighter, more sedentary. The abilities called upon are less esoteric, more generally available in the working population outside print. Inputting requires little more than good typing ability on the QWERTY board, something possessed by many more women than men. The implications for compositors of this twist in their craft history are dramatic. Combined with a recession it is causing unemployment in the trade, something unknown since the thirties. The individual tasks in the overall process have become trivialized and the men feel the danger of increased sub-division, routinization and substitution of unskilled workers.

The union response has not been to reject the new technology. Instead it has fought an energetic battle to retain the right to the new equipment as it did to the old. It resists 'direct input' by outsiders, asserts exclusive right to the photosetting keystroke (if necessary to a redundant second typing), to paste-up and the control of the photosetters, and where possible the computers. It is demanding increased pay and reduced hours in exchange for agreement to operate the new technology. And it is insisting (in principle at least) that all composing personnel get the chance to retrain for all aspects of the *whole* photocomposing job . . . an uphill struggle for reintegration of the now transformed craft.

An extensive literature has demonstrated the effect of craft organization on the structure of the working class. 'The artisan creed with regard to the labourers is that the latter are an inferior class and that they should be made to know and kept in their place' (Hobsbawm, 1964). The loss of demands on manual skill brought about by electronic photocomposition does not necessarily mean the job has become more 'mental'. On the contrary, present-day compositors feel their new work could be done by relatively unskilled workers. Many members feel they have lost status and some resent the strategic necessity to seek amalgamation of the National Graphical Association (NGA) with the unions representing the less skilled.

Our account shows, however, that the purposeful differentiation between skilled and unskilled workers was also a step in the construction of *gender*. This is a more recent conception. Heidi Hartmann has suggested that 'the roots of women's present social status' lie in job segregation by sex and demonstrates the role of men and their unions in maintaining women's inferiority in the labour market by deployment of skill (Hartmann, 1979b). The fact that females in the closed-shop NGA (which embodies a large proportion of the better paid workers in the printing industry) until recently amounted to no more than 2% of its membership is directly connected with the fact that women's average earnings have always been lower relative to men's in printing than in manufacturing occupations as a whole. Through the mechanisms of craft definition women have been constructed as relatively lacking in competence, and relatively low in earning power. Women's work came to be seen as inferior. Now that the new composing process resembles 'women's work' stereotypes it is felt as emasculating. The skill crisis is a crisis of both gender and class for comps.

Anne Phillips and Barbara Taylor propose that skill is a direct correlate of sexual power. 'Skill has increasingly been defined against women . . . far from being an objective economic fact, skill is often an ideological category imposed on certain types of work by virtue of the sex and power of the workers who perform it' (Phillips and Taylor, 1980).

It is important to recognize this ideological factor. It has become increasingly important in printing with the advance of technology. The compositor sitting at a keyboard setting type is represented as doing skilled work. A girl typist at a desk typing a letter is not – though the practical difference today is slight. Nonetheless, the formulation here again, posing the ideological as foil to the economic, leads to an under-emphasis on the material realities (albeit socially acquired) of physical power and with them the tangible factors in skill which it is my purpose to reassert.

Phillips and Taylor cite several instances of job definition where the distinction between male and female jobs as skilled and unskilled is clearly no more than ideological. But in printing, and perhaps in many other occupations too, unless we recognize what measure of reality lies behind the male customary over-estimate of his skill we have no way of evaluating the impact of electronic photocomposition, the leeching out of the tangible factors of skill from some tasks and their relocation in others, out of the compositor's reach.

What was the hot metal compositor's skill? He would say: I can read and calculate in a specialized manner; I can understand the process and make decisions about the job; I have aesthetic sense; I know what the tools are for and how to use them; I know the sequence of tasks in the labour process; how to operate, clean and maintain the machinery; I am dexterous and can work fast and accurately under pressure, can lift heavy weights and stand for hours without tiring. No one but an apprenticed compositor can do ALL these things.

There are thus what we might call tangible factors in skill – things that cannot be acquired overnight. They are both intellectual and physical and among the physical are knack, strength and intimacy with a technology. They are all in large measure learned or acquired through practice, though some apprentices will never make good craftsmen. The relative importance of the factors shifts over time with changing technology. Skill is a changing constellation of practical abilities of which no single one is either necessary or sufficient. Cut away the need for one or two of them and the skill may still be capable of adaptation to remain intact, marketable and capable of defence by socio-political organization.

The tangible factors in skill may be over-stated for purposes of self defence and are variably deployed in socio-political struggle. Thus, against the unskilled male, defined as corporally superior to the skilled, hot metal comps have defended their craft in terms of (a) its intellectual and (b) its dexterity requirements. Against women, with their supposed superior dexterity, the skilled men on the contrary used to invoke (a) the heavy bodily demands of the work and (b) the intellectual standards it was supposed to require.[10] (Among comps today it is sometimes done to keep a list of the 'howlers' they detect in the typescripts coming to them from the 'illiterate' typists upstairs.)

The bodily strength component of the compositor's craft may be isolated to illustrate the politics involved. Men, having been reared to a bodily advantage, are able to make political and economic use of it by defining into their occupation certain tasks that require the muscle they alone possess, thereby barricading it against women who might be used against them as low-cost alternative workers (and whom for other reasons they may prefer to remain in the home). In composing, the lifting and carrying of the forme is a case in point. Nonetheless, many compositors found this aspect of the work heavy and it was felt to be beyond the strength of older men. They were always torn between wishing for unskilled muscular assistants and fearing that these, once ensconced in part of the job might lay claim to the whole.

The size and weight of the forme is arbitrary. Printing presses and the printed sheet too could have been smaller. And heavy as it is, the mechanization exists which could ease the task. It is, in printing, purely a question of custom at what weight the use of hoists and trolleys to transport the forme is introduced.

Units of work (hay bales, cement sacks) are political in their design. Capitalists with work-study in mind and men with an interest in the male right to the job both have a live concern in the bargain struck over a standard weight or size. But the political power to design work processes would be useless to men without a significant average superiority in strength or other bodily capability. Thus the appropriation of bodily effectivity on the one hand and the design of machinery and processes on the other have often converged in such a way as to constitute men as capable and women as inadequate. Like other physical differences, gender difference in average bodily strength is not illusory, it is real. It does not necessarily matter, but it can be made to matter. Its manipulation is socio-political power play.

Above everything, a skill embodies the idea of wholeness in the job and in the person's abilities, and what this 'whole' comprises is the subject of a three-way struggle between capital, craftsman and the unskilled. The struggle is over the division of labour, the building of some capabilities into machines (the computer, the robot), the hiving off of some less taxing parts of the job to cheaper workmen, or to women. Craft organization responds to capitalist development by continually redefining its area of competence, taking in and teaching its members new abilities. Wholeness has become of key significance to the compositors' union as electronic technology has trivialized and shifted the pattern of the individual tasks. Socio-political organization and power have become of paramount importance as the old tangible physical and intellectual factors have been scrapped along with the old hardware.

Control of technology

Capitalists as capitalists and men as men both take initiatives over technology. The capitalist class designs new technology, in the sense that it commissions and finances machinery and sets it to work to reduce the capitalist's dependency on certain categories of labour, to divide, disorganize and cheapen labour. Sometimes machinery displaces knack and know-how, sometimes strength. Yet it is often the knowledge of the workers gained on an earlier phase of technology that produces the improvements and innovations that eventually supersede it. For instance, in a radical working men's paper in 1833, claiming rights over the bosses' machines, the men say: '*Question:* Who are the inventors of machinery? *Answer:* Almost universally the working man' (Berg, 1979: 90).

In either case, it is overwhelmingly males who design technological processes and productive machinery. Many women have observed that mechanical equipment is manufactured and assembled in ways that make it just too big or too heavy for the 'average' woman to use. This need not be conspiracy, it is merely the outcome of a pre-existing pattern of power. It is a complex point. Women vary in bodily strength and size; they also vary in orientation, some having learned more confidence and more capability than others. Many processes could be carried out with machines designed to suit smaller or less muscular operators or reorganized so as to come within reach of the 'average' woman.

There are many mechanized production processes in which women are employed. But there is a sense in which women who operate machinery, from the nineteenth-century cotton spindles to the modern typewriter, are only 'lent' it by men, as men are only 'lent' it by capital. Working-class men are threatened by the machines with which capital seeks to replace them. But as and when the machines prevail it is men's hands that control them. Comps now have twice adopted new technology, albeit with bad grace, on the strict condition that it remain under their own control. They necessarily engage in a class gamble (how many jobs will be lost? will wages fall?) but their sexual standing is not jeopardized.

The history of mechanized typesetting offers an instance of clear sex-bias within the design of equipment. The Linotype manufacturing company has twice now, in contrast to its competitors, adopted a policy that is curiously beneficial to men. A nineteenth century rival to the Linotype was the Hattersley typesetter. It had a separate mechanism for distributing type, designed for use by girls. The separation of the setting (skilled) from dissing (unskilled) was devised as a means of reducing overall labour costs. A representative of the Hattersley company wrote 'it would be a prostitution of the object for which the machine was invented and a proceeding against which we would protest at all times' to employ *men* on the disser (Typographical Association, 1893).

The Linotype machine on the other hand did not represent the destruction but merely the mechanization of the comp's setting skills as a *whole*. In fact, the LSC congratulated the Linotype Company Ltd. 'The Linotype answers to one of the essential conditions of trade unionism, in that it does not depend for its success on the employment of boy or girl labour; but on the contrary, appears to offer the opportunity for establishing an arrangement whereby it may be fairly and honestly worked to the advantage of employer, inventor and workman' (Typographical Association, 1893). While Linotype were not above using male scab trainees when driven to it by the comps' ca'canny, they never tried to put women on the machines and indeed curried favour with the LSC by encouraging employers who purchased the machine to shed female typesetters and replace them with union men.

Ninety years on, Linotype (now Linotype Paul) are leading designers and marketers of electronic composing systems. Most present day manufacturers, with an eye to the hundreds of thousands of low-paid female typists their clients may profit from installing at the new keyboards, have designed them with the typewriter QWERTY lay, thus reducing Lino operators at a single blow to fumbling incompetence. Linotype Paul is one of the few firms offering an optional alternative keyboard, the 90-key lay familiar to union comps. Once more, they seem to be wooing the organized comp as man and in doing so are playing, perhaps, an ambivalent part in the class struggle being acted out between print employers, craftsmen and unskilled labour (since employers would profit more by the complete abolition of the 90-key board).

Now, electronic photocomposition is an almost motionless labour process. The greatest physical exertion is the press of a key. The equipment is more or less a 'black box'. The intelligence lies between the designers, maintenance engineers and programmers and the computer and its peripherals. Only the simplest routine processes and minimal decisions are left to the operator.

Two factors emerge. It is significant that the great majority of the electronic technical stratum are male (as history would lead us to expect). Male power deriving from prestigious jobs has shifted up-process leaving

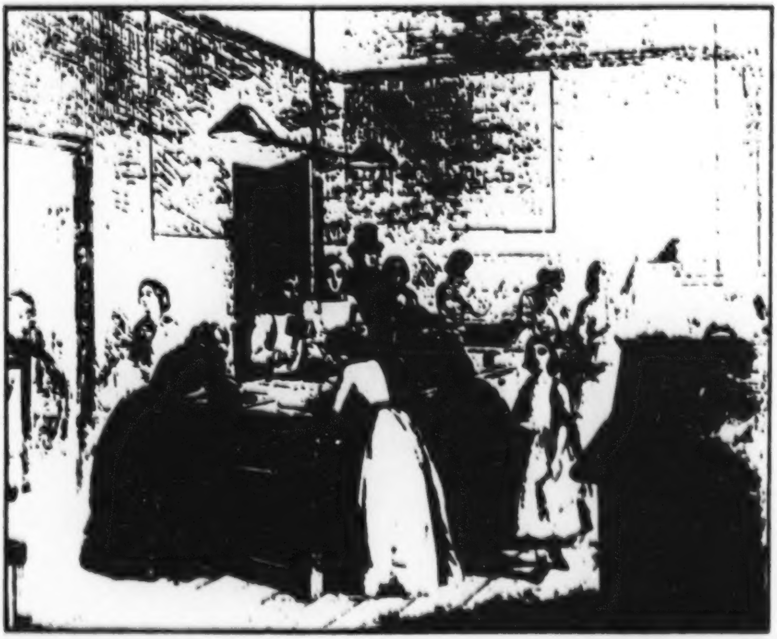

Figure 3 *The Victoria Press in Great Coram Street, London, for the employment of women compositors, 1861.*

the compositor somewhat high and dry, vulnerable to the unskilled and particularly to women. In so far as he operates this machinery he has a 'female' relationship to it: he is 'lent' it by men who know more about its technicalities than he does.

The NGA, faced with a severe threat to composing as a craft, has been forced into innovatory manoeuvres in order to survive as a union. It is widening its scope, radically re-designing and generalizing its apprenticeship requirements, turning a blind eye to the fact that some of the new style comps it recruits 'on the job' come in without apprenticeships (and a handful of these are now women who have graduated from typing to simple composers). It is seeking to recruit office workers, a proportion of whom will be female typists who are seen as a weapon employers may try to use against comps. They are to be organized in separate division within the union and thus will be under supervision by the union but not permitted to invade the area of existing comps' work.

Conclusion: men's power and patriarchy

This study has been of the workplace. Marxist theory proposed the workplace as the primary locus of capitalist exploitation, while women's disadvantage was seen as having its site in the property relations of the family. The corollary of this view was the belief (disproved by the passing of time) that women would evade their subordination to men when they came out into waged work (Engels, 1972). Feminists have shown on the contrary that the family, as the throne of 'patriarchy', has its own malevolent effectivity within capitalism and capitalist relations, it pursues women out into waged work (Kuhn, 1978; Bland, 1978).

Many women, however, are relatively detached from conjugal or paternal relationships. Many are single, childless, widowed, live independently, collectively, without husbands, free from fathers. Can 'the family' satisfactorily account today for the fact that they hesitate to go to the cinema alone, have to call on a man to change a car wheel, or feel put out of countenance by walking into a pub or across a composing room floor? Our theories of sexual division of labour at work have tended to be an immaculate conception unsullied by these physical intrusions. They read: women fill certain inferior places provided by capitalism, but do so in a way for which they are destined by the shackles of family life. The free-standing woman, the physical reality of men, their muscle or initiative, the way they wield a spanner or the spanner they wield, these things have been diminished in our account.

The story of compositors, for me, throws doubt on the adequacy of the explanation that the sexual relations of work can be fully accounted for as a shadow cast by the sex-relations of the family. It seems to me that the construction of gender difference and hierarchy is created at work as well as at home – and that the effect on women (less physical and technical capability, lack of confidence, lower pay) may well cast a shadow on the sex-relations of domestic life.

In socialist-feminist thought there has been a clear divide between production (privileged site of class domination) and the family (privileged site of sexual domination). The patriarchal family is recognized as adapted to the interests of capital and the capitalist division of labour as being imprinted with the patterns of domestic life. They are conceded to be mutually effective, but are nonetheless still largely conceived as two separate spheres, capitalism holding sway in one, patriarchy in the other.

Yet the compositors' story reveals a definable area of sex-gender relations that cannot be fully subsumed into 'the family', an area which has tended to be a blindspot for socialist-feminist theory. It is the same as that spot within the class relations of wage labour and capitalist production, invisible to Marxist theory, in which male power is deployed in the interests of men – capital apart.

In our analysis we can accommodate men as 'patriarchs', as fathers or husbands, and we can accommodate capitalists and workers who are frequently men. But where is the man as male, the man who fills those spaces in capitalist production that he has defined as not ours, who designs the machines and thereby decides who will use them? Where is the man who decorates the walls of his workplace with pin-ups of naked women and whose presence on the street is a factor in a woman's decision whether to work the night shift?

It was an incalculable breakthrough in the late sixties when the sexual relations of private life came to be more generally recognized as political. But somehow those sexual relations have remained ghettoized within the family. Only slowly are we demolishing the second wall, to reveal in theory what we know in practice, that the gender relations of work and public life, of the factory and the street, are sexual politics too.[11]

It is in this sense that the prevailing use of the concept of 'patriarchy' seems to me a problem. Some feminists have argued, I think rightly, that it is too specific an expression to describe the very diffuse and changing forms of male domination that we experience, and that it should be reserved for specific situations where society is organized through the authority of fathers and husbands over wives and offspring and of older men over younger men (Young and Harris, 1976).

Such a 'patriarchy' would usefully enable us, for instance, to characterize certain historical relations in the printing industry: the archaic paternalism of journeyman-apprentice relations, the handing of job from father to son, the role of the 'father' of chapel in the union etc. But these practices are changing in printing – just as Jane Barker and Hazel Downing have shown that patriarchal relations of control in the office are being rendered obsolete by the new capitalist office technology (Barker and Downing, 1980).

Do we then assume that male supremacy is on the wane in the workplace?

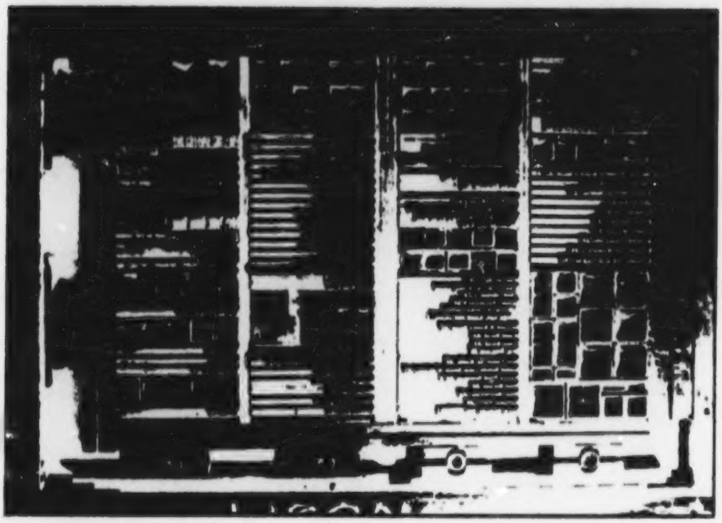

Figure 4 *A made up forme.*

I think not. The gap between women's earnings and men's in printing has widened in the last few years. What we are seeing in the struggle over the electronic office and printing technology is a series of transformations within gender relations and their articulation with class relations. The class relations are those of capitalism. The gender relations are those of a wider, more pervasive and more long-lived male dominance system than patriarchy. They are those of a sex-gender system[12] in which men dominate women inside and outside family relations, inside and outside economic production, by means which are both material and ideological, exercising their authority through both individual and organizational development. It more nearly andrarchy[13] than patriarchy.

Finally, in what practical sense do these questions matter to women? Seeing bodily strength and capability as being socially constructed and politically deployed helps us as an organized group in that we can fight for the right to strengths and skills that we feel to be useful. On the other hand, where we do not see this kind of power as socially beneficial, our struggle can seek to devalue it by socio-political means in the interests of a gentler world (or to prevent our being disadvantaged by what may turn out to be our few remaining innate differences).

Identifying the gendered character of technology enables us to overcome our feelings of inferiority about technical matters and realise that our disqualification is the result not of our own inadequacy, nor of chance, but of power-play. Understanding technology as an implement in capital's

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struggle to break down workers' residual control of the labour process helps us to avoid feeling 'anti-progress' if and when we need to resist it. Understanding it as male enables us to make a critique of the exploitation of technology for purposes of power by men – both over women and over each other, in competition, aggression, militarism.

Unless we recognize what capital is taking away from some men as workers, we cannot predict the strategies by which they may seek to protect their position as men. As one technology fails them will they seek to establish a power base in another? Will they eventually abandon the de-skilled manual work to women, recreating the job segregation that serves male dominance? Or will the intrinsic interdependency of keyboard and computer force a re-gendering of 'typing' so that it is no longer portrayed as female? As men's physical pre-eminence in some kinds of work is diminished will they seek to reassert it heavily in private life? Or is the importance of physical effectivity genuinely diminishing in the power relations of gender? Can the unions, so long a socio-political tool of men, be made to serve women? We need to understand all the processes that form us as workers and as women if we are to exert our will within them.

Thanks for helpful criticism of this paper in draft to Marianne Craig, Jane Foot, Nicola Murray, Anne Phillips, Eileen Phillips, Caroline Poland, Mary Slater, Judy Wajcman, Kate Young and members of the *Feminist Review* collective.

Notes

1 The article is based on a project in progress, 'Skilled printing workers and technological change', funded by the Social Science Research Council and carried out at The City University, London. The paper was first given at the annual conference of the British Sociological Association in 1981.

2 The fact that a mode of production and a sex-gender system are two fundamental and parallel features of the organization of human societies should not lead us to expect to find any exact comparability between them, whether the duo is capitalism/'patriarchy' or any other. In the case of a sex-gender system there is a biological factor that is strongly, though not absolutely, predisposing. This is not the case in a class system. The historical timescale of modes of production appears to be shorter than that of sex-gender systems. And the socio-political and economic institutions of class seem to be more formal and visible than those of gender – though one can imagine societies where this might not be the case.

3 Michèle Barrett's recent book reviews in detail the progress of this endeavour (Barrett, 1980). An important contribution to the 'appropriation of patriarchy by materialism' has been Kuhn and Wolpe (1978).

4 I adopt here Michèle Barrett's useful re-assertion of the distinction between ideology and 'the material', in place of a simplistic fusion 'ideology is material'. She cites Terry Eagleton, 'there is no possible sense in which meanings and values can be said to be "material", other than in the most sloppily metaphorical use of the term . . . If meanings

are material, then the term "materialism" naturally ceases to be intelligible' (Barrett, 1980: 89–90).

5 Heidi Hartmann's definition of patriarchy is novel in including 'hierarchical relations between men and *solidarity among them*' (Hartmann, 1979b).

6 For instance, children whose families' low income entitles them to free school milk are shorter than the average child (demonstrated in article in *The Lancet*, 1979). More information relating class and stature should be available from Department of Health and Society Security 'Heights and Weights Survey' to be published 1982.

7 Griffiths and Saraga (1979) have argued the same of sex difference in cognitive ability.

8 A fuller account exists in Cynthia Cockburn (1980) 'The losing battle: women's attempts to enter composing work 1850–1914', Working Note No. 11, unpublished.

9 I have traced the course of this technological development in 'The Iron Comp: the mechanization of composing', Working Note, No. 10, 1980, unpublished.

10 For an interesting discussion of 'dexterity' versus 'skill' in relation to gender see Ramsay Macdonald (1904).

11 A sign of change in this direction was Farley (1980), concerning sexual harrassment of women at work.

12 Gayle Rubin's term (Rubin, 1975).

13 Rule by *men* as opposed to rule by fathers or male heads of household or tribe, cf. androgynous, polyandry, andro-centrism.

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